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Adaptability Improvement of Jambi Local and National Rice Genotypes to Acid Sulphate Tidal Swampland Using Ameliorants

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ABSTRACT

Research on the adaptability of Jambi local rice and national rice varieties for cultivation under acid sulfate tidal swamp land with the application of ameliorants has been carried out in tidal swamp rice fields in Pembengis Village Bram Hitam District West Tanjung Jabung Regency Jambi Province from April to September 2021. Ten local and national rice varieties were evaluated including Kuatik Tinggi Kuatik Rendah Karya Tinggi Karya Rendah Karang Duku Bujang Berinai Pandan Wangi Padi Belanda Inpara and Inpari. Whereas Ameliorant treatments consisted 4 kinds namely without ameliorant (control) dolomite lime rice husk ash and areca-nut-fiber ash. The results of the experiment showed that there was an influence of local rice plant varieties on vegetative growth with the treatment of several rice plant varieties having a significant effect on rice plant height and significantly affecting panicle length number of per panicle grain and grain yield but for the treatment parameters the maximum number of tillers and the number of productive tillers has no significant effect. Addition of ameliorants: dolomite lime rice husk ash and areca nut fiber ash) showed reduction on rice plant height maximum number of tillers number of productive tillers panicle length number of grains per panicle number of grains without panicles and grain yield. .

INTRODUCTION

Jambi Province one of the provinces targeted for regional expansion and increase in national rice production has enormous potential area of rice cultivation. From the data owned by the Central Bureau of Statistics for Jambi Province in 2018 it was recorded that West Tanjung Jabung Regency is one of the districts that has a relatively large rice harvest area with 10107 hectares and high productivity so that it is projected to become the main food crop agriculture center in Jambi Province. A total of 2500 ha of rice fields were distributed in 8 districts/cities including Tebo District 500 ha Sarolangun 500 ha Merangin 500 ha Bungo 200 ha Batanghari 300 ha Tanjung Jabung Barat 2364 ha Kerinci 230 ha and Sungai Full

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100 ha (Saidi et al 2020). In addition there were still 52052 hectares of sub-optimal land in the form of tidal swamp land. Tidal land has a potential agro-ecosystem for agricultural development especially food crops. There were two main types of soil in tidal areas namely mineral soils and peat soils (Subagyo 2006). Soil Taxonomy (Soil Survey Staff 2010) the soil in swamps is classified in three great group: (1) marine alluvial soil (Sulfaquent Sulfaquept Hydraquent Fluvaquent) (2) river alluvial soil (Endoaquent Endoaquept) and (3) peat soil (haplofibrist/hemist Sulfihemist/ saprist Sulfohemis/saprist).

The productivity of this tidal lands is still relatively low but improvements can be implemented to support the efforts to increase production of the main food crops in Jambi Province. There were land improvements alternatives that can be applied based on the technology components of Integrated Crop Management (ICM) for increasing rice productivity in tidal land. These include (1). Selection of superior adaptive rice varieties (2). Water management system (3). Land preparation (4). Management of nutrients and ameliorants (5). Integrated weed control and (6). Determination of cropping pattern. Therefore of the 6 components of PTT technology the most rational component to be implemented taking into account the capabilities of local farmers were the use of adaptive superior rice seeds and the use of available agricultural waste as a form of nutrient management and amelioran to obtain increased productivity of rice plants.

Most of farmers in tidal swamp land (90%) cultivate local varieties of rice once a year. Only 10% of farmers grow superior rice varieties. The reason for farmers planting local rice is because of the ease of cultivation does not require high inputs the high selling price of rice and the taste of rice is preferred by local consumers (Wahdah and Langai 2010). In addition local varieties were adaptive to tidal swamp land even though the seedlings were old (2-3 months) they can still be planted. However this is not the case for superior varieties. To increase rice production in tidal swamps it is necessary to select local and national superior varieties that were adaptive have high yield potential and yield quality. In addition the addition of various kinds of ameliorant which were readily available in Jambi Province should be evaluated to improve the tidal swamp soil quality.

MATERIALS AND METHOD

The research was conducted in tidal swamp rice fields in Pembengis Village Bram Hitam District West Tanjung Jabung Regency Jambi Province. The research duration was approximately 5 months starting from April to September 2021.

This research was conducted using a Split Pot Design which consisted of 2 treatment factors namely variety and ameliorant. We tested local and national rice varieties (V) obtained from local farmers namely: Kuatik Tinggi (V1) Kuatik Rendah (V2) Karya Tinggi (V3) Karya Rendah (V4) Karang Duku (V5) Bujang Berinai (V6) Pandan Wangi (V7) Padi Belanda (V8) Inpara (V9) and Inpari (V10). In the case of ameliorant four kinds of ameliorant (A) namely: without amelioran control (A0) dolomite lime (A1) rice husk ash (A2) and Ash of Areca Nut Fiber (A3).

The tools used were handtractors hoes rakes tape measure markers digital and dacing scales sprayers raffia rope nameplates stationery needed for research. Ameliorant materials used were rice husk ash areca nut coir ash (the manufacturing process) and dolomite lime as controls. Weed eradication was carried out at the beginning of land management in the form of contact and systemic herbicides (Tepulalang and Kintek); whereas fertilization was done according to farming recommendation standards in the form of Urea KCl and SP-36.

Research Implementation

The experimental area was prepared through clearing weeds directly using a handtractor; while muddying the land followed by making a research plot with a size of 100 cm x 650 cm and building irrigation channels and bunds using neat ropes and a hoe. The distance between the research plots was 80 cm and the distance between replicates was 80 cm. Each plot was made of small bunds/embankments to separate one plot from another so that the treatment given to each plot does not mix with other plots when the rice fields were flooded with water. Incoming and outgoing water was made not parallel so that the rice fields can be irrigated evenly.

Seeding was carried out in seedbeds at the location of the research area. The seeds of 10 varieties were selected and soaked in water for 24 hours to stimulate germination and root growth. After the seeds germinate they were sown in a nursery and then transferred in the field after 14 days. The seedling areas were water flooded for 1 day with a height of 2 to 5 cm so that the soil was soft and seedling were easily uprooted for replanting into the research field area. The seed beds for each variety were labeled.

Before the treatments were applied to the research location the Ameliorant materials in the form of Dolomite lime rice husk ash and areca coir ash were prepared and the Calcium (Ca) content was measured at the Jambi Agricultural Technology Study Center so that the materials needed for research can be counted. The application of Dolomite lime to the research plots referred to the general recommendation for the dosage given for tidal swamp land which is 1.3 tons per hectare (Krisnawati and Cahyoadi 2019).

The application of fertilizer referred to the standard recommendation of fertilization by the Rice Research Institute namely 3 times. Basic fertilizer was applied to the plot before the seeds were planted at ½ fertilizer dose by spreading it evenly each plot in the morning. Subsequent fertilization was given at the age of 14 days after planting (DAP) with a dose of Urea 90 g/plot KCl 32.5 g/plot and SP-36 32.5 g/plot. The last fertilization was carried out at 49 DAP with a dose of Urea 90 g/plot KCL 32.5 g/plot and SP-36 32.5 g/plot.

Planting of rice seedlings (transplanting) was carried out at 21 days after sowing. Two seedlings were planted in plots with a spacing of 25 cm x 25 cm in each planting hole with a depth of 3-4 cm. Seedlings of a suitable variety were placed in each plot.

Irrigation was done just up to the soil surface following planting and water only filled the irrigation canals. At each edge of the plot a door was made for regulating the entry and exit of water in each plot.

Replanting was conducted if seedlings were dead at 1 week after planting. Irrigation of rice fields is carried out according to the pattern of rice cultivation in the study area and according to their needs. Weeding was performed by pulling the grass at the spacing area between the plants by hand at 3 6 and 10 WAP.

Rice plants was harvested when the seeds at physiological maturity in which when 90% the grains was hard the color of the flag leaf and panicles has turned yellow. In addition the stems of the plants begin to dry (yellow phase) because in this phase the production results were the highest.

Plant height was measured from the ground surface to the tip of the highest panicle using measuring tape sticked of a bamboo stake. Maximum number of tillers of a clump was calculated from each sample plant clump by counting the total number of tillers at 6 WAP. The number of productive tillers was carried out at 90 DAP by counting the number of tillers that produced panicles in each sample plant clump. Panicle length was measured out after harvest using a ruler by taking 5 panicles from each sample clump and measuring from the first panicle to the tip of the panicle. Number of grains per panicle were counted manually by taking 3 panicles from each sample clump after harvest. Percentage of empty grain per panicle was observed by counting empty grains of 3 panicles from each sample clump with grain units and being calculated using following formula:

% Empty Grain = (Number of empty grains per panicle / Total grain number per panicle) X 100 %

Grain yield per plot was evaluated following the seeds were dried until seed moisture content of 12% the best dryness for rice milling.

Soil sampling of the research areas consisted of two stages. First one initial soil sample was taken in a composite manner as much as 3 kg from 3 locations before being given any treatment at the research location. Second 12 final soil samples each of 3 kg were taken from each land treatment plots (without treatment dolomite rice husk ash and areca nut coir ash). Each soil sample was put into a plastic bag for further analysis for the macro nutrient content available in the form of Sodium phosphorus potassium organic C Al-dd Fe and soil pH. Soil analysis was carried out in the Laboratory of the Soil Research Institute of Balitbangtan - Ministry of Agriculture Cikupa Bogor.

RESULTS AND DISCUSSION

Effect of Ameliorant

Addition of ameliorant used in this experiment including dolomite lime rice husk ash and areca nut fiber ash had negative effects all observed variables of plant growth and grain yield (Table 1). Plant height as compared to control plants (100 cm) was constrained by the addition of ameliorants with less reduction was observed under addition of dolomite lime (87cm) than those under rice husk ash and areca fiber ash (83 cm and 82 cm respectively).

Maximum tiller number of rice plant was reduced less under addition of dolomite lime or rice husk ash (17 tillers each) from control (18 tiller) than those under addition of areca nut fiber ash (15 tillers). This phenomenon was similar to number of productive tillers with greatest reduction occur with the addition of areca nut fiber ash (12 tillers) from those under control 15 tillers). On the other hand additions of dolomite lime and of rice husk ash did not affect rice panicle length (13.25 cm and 13.88 cm) from those under control (15.23 cm); but under addition of areca nut fiber it was reduced to 10.09 cm).

In term of reproductive development the number of grains per panicle was reduced by addition of ameliorants from 125 grains those under control to 110 grains under dolomite lime addition 107 grains under rice husk ash and further 90 grains under areca nut fiber ash (Table 1). Similarly the percentage of empty grains per panicle followed those of grain number per panicle with the order of control dolomite lime addition rice husk addition and areca nut fiber addition (23% 20% 17% and 16% respectively). Finally grain dry weight also followed similar order with those grain numbers. Control plants produced greatest grain dry weight (13.72 kg) followed by those under addition of dolomite of rice husk ash and areca nut fiber ash (11.46 kg 8.67 kg and 7.27 kg).

Evaluated ten rice genotypes varies in their growth and yield characters when grown under acid tidal swampland except those of number of grains per panicle (Table 2). Plant height wide-ranging with the tallest structures were found for Karang Duku and Inpara (95.6 cm and 94.4 cm respectively) whereas the shortest were Pandan Wangi and Karya Tinggi (82.2 cm and 83.3 cm). The tested rice genotypes also varied in term of maximum tiller number from 13 tillers for Inpari to 19 tillers in Pandan Wangi. In accordance with this the number of productive tillers also followed with the least number for Inpari (10 tillers) and the greatest number for Pandan Wangi (16 tillers). In term of panicle length Pandan Wangi had the

Table 1. Effect of addition ameliorant types into acid sulphate tidal swampland on growth and production of rice plants

Treatment	Plant Height (cm)	Maximum Tiller Number	Number of Productive Tillers	Panicle Length (cm)	Number of Grain per panicle	Empty Grain Per Panicle (%)	Grain Dry Weight (kg)
Control	100.21c	18.23c	15.23 b	22.76b	125.21 d	22.46 d	13.72d
Dolomite Lime	87.47b	16.88 b	13.25 ab	23.00b	109.50c	19.86 c	11.46c
Rice Husk Ash	83.22a	16.88 b	13.88 ab	22.99 b	107.24b	17.07 b	8.67b
Areca-Nut-Fiber Ash	82.05a	15.01 a	12.01a	10:09 a	90.20a	15.67 a	7.27a

shortest panicle (2125 cm) whereas Kuatik Tinggi and Karang Duku genotypes showed the longest panicles (23.28 cm and 23.48 cm respectively).

For yield characters ten rice genotypes tested did not diversed in term of number of grains per panicle but varied in term of the number of empty grains per panicle and grain weight per plot (Table 2). The numbers of empty grains of Karang Duku and Inpara genotype (17 grains) were the lowest number as compared to those of others. On the other hand in the case of empty grain percentage Inpari and Inpari genotypes demonstrated the greatest percentage of empty grains (20%) than others; whereas Karang Duku and Inpara showed the lowest percentage of empty grain (17%). Lastly the yield of grains per plot varied greatly among tested genotypes in the order of (from the greatest) Pandan Wangi (12.29 g) > Karang Tinggi (11.82 g) > Kuatik Rendah (11.71 g) > Inpari (11.18 g) > Bujang Berinai (10.26 g) > Karya Rendah (9.79 g) Kuatik Tinggi (9.51 g) padi Belanda (9.51 g) Karang Duku (9.35 g) > Inpara (8.82 g).

The results of the initial soil analysis test before treatment applied showed that the soil used for the experiment have pH 5.49 C organic 9.06. Phosphorus (P) available 15.0 Potassium (K) 1.33. Sodium (Na) 8.62. Aluminum (Al) 0.48 and Hydrogen (H) 0.37. From the results of soil analysis tests after being given the Dolomite Lime treatment it was found that there was a decrease in pH to 5.22. This could be caused by waterlogging which had occurred 2 times during the planting period which resulted in an increase in the solubility of elements contributing to soil acidity such as Al and Fe. Organic C increased to 12.22. Available phosphorus (P) decreased to 7.13 Potassium (K) also decreased to 0.74. Sodium (Na) 7.44. Aluminum (Al) 1.23 and Hydrogen (H) 0.28. In the rice husk ash treatment there was also a decrease in pH to 4.55 organic C increased to 12.93. Available phosphorus (P) 5.17 potassium (K) 0 83. Sodium (Na) 8.9. Aluminum (Al) 2.7 and Hydrogen (H) 0.46. After being given the Areca-Nut-Fiber Ash treatment the pH also decreased to 4.48. C organic 13.32. Available phosphorus (P) 5.60 Potassium (K) 1.27. Sodium (Na) 10. Aluminum (Al) 2.91 and Hydrogen (H) 0.4.

Discussion

Growth is a process in plant life that results in changes in size weight gain stem volume and diameter from time to time and is controlled by growth factors. There were two important factors that influence the growth of a plant namely genetic factors and environmental factors. Genetic factors were related to the inheritance of the properties of the plants themselves whereas environmental factors were related to the surrounding conditions in which the plants grow. Each plant has different

Table 2. Growth and production of rice plant genotypes grown under tidal swampland

Genotype	Plant Height (cm)		Maximum Tiller Number		Number of Productive Tillers		Panicle Length (cm)		Number of Empty Grain per Panicle		Grain Dry Weight (kg)	
Kuatik Tinggi	90.70	cd	16.23	abc	13.23	abc	23.28	f	17.69	b	9.51	bc
Kuatik Rendah	86.33	abc	17.98	bc	14.98	bc	21.98	b	19.11	e	10.71	f
Karya Tinggi	83.25	a	18.56	bc	15.56	bc	22.51	c	20.22	f	11.82	g
Karya Rendah	89.65	c	16.88	abc	13.88	abc	22.96	de	18.72	d	9.79	c
Karang Duku	95.63	e	18.20	bc	15.20	cb	23.48	f	16.94	a	9.35	b
Bujang Berinai	86.10	abc	14.75	ab	11.75	ab	22.66	cd	19.11	e	10.26	d
Pandan Wangi	82.21	a	19.41	c	16.41	c	21.25	a	20.69	h	12.29	h
Padi Belanda	89.30	bc	14.86	ab	11.86	ab	22:53	c	18.36	c	9.51	bc
Inpara	94.48	de	15.81	abc	12.81	abc	24.06	g	17.16	a	8.32	a
Inpari	84.71	ab	13.2	a	10.23	a	22.33	bc	19.58	f	11.18	f

abilities in terms of utilizing growing resources and the ability to adapt to the surrounding environment thus affecting the yield potential of plants (Adrianto et al. 2014). Continuing plant development such as thickening of the cell wall hardening of the protoplasm and filling of grain) is determined by net photosynthate after the needs for growth are met and the temperature supports and the presence of the right enzyme systems involved during the differentiation takes place (Tambing and Made 2005).

Plant height growth does not guarantee high plant productivity. Plants that grow well were able to absorb large amounts of nutrients the availability of nutrients in the soil affects plant activities including photosynthetic activity so that plants can increase growth and production (Aribawa 2012).

The height of the stem of the plant is influenced by the characteristics that affect the yield of the variety. Based on the characteristics of plant height varieties that have short plant heights can be caused by several factors such as climate factors or other factors. The taller the plant the higher the tendency to collapse. Varieties that have short stems will be able to absorb more sunlight compared to the absorption of sunlight by varieties that have taller stem sizes (Suprihatno 2010). This is because with long stems the ability of sunlight and the intensity of the sun to penetrate the canopy (canopy) of the plant to the bottom of the plant above the ground will be much reduced compared to plants that have low stems.

The number of tillers is a genetic trait and plays an important role in determining the productivity of lowland rice plants. Plants with the ability to form a high number of tillers were predicted to have higher productivity compared to plants with a small number of tillers. This of course must be supported by adequate growth and environmental factors (Dedi and Wahyu 2016). There were quite a lot of active tillers formed because the plants were grown under ideal conditions there were no limiting factors from the biotic or abiotic environment including space in the formation of tillers. This condition proves that the number of offspring is influenced by genetic traits where adaptability is also one of them.

Productive tillers were produced by providing balanced nutrients. Balanced fertilization is the application of fertilizer to the soil with the aim of achieving essential and optimum soil nutrient status conditions so as to increase soil fertility quality and production yields fertilization efficiency and reduce environmental pollution (Setyorini et al. 2006). Yoshida (1981) explained that plant density affects total and productive tillers.

Differences in panicle among varieties were caused by genotypic differences namely the length of the vegetative phase of each variety. The growth of the vegetative phase of the plant ends with the release of the panicle which is called the generative phase. At this stage the plant begins to allocate its assimilates to the panicle. If the plant has a long vegetative phase it can slow down the panicle formation process. Maisura (2001) added that increasing vegetative growth increases the formation and development of panicles.

Panicle emergence is caused by plant genetic factors namely plant age and environmental factors. An increase in panicle length is usually caused by an increase in the number of tillers that produce panicles if the number of tillers is small the panicle length formed is also short. An increase in panicle length affects grain yields. It can be stated that the increase in the panicle length enable the stalk to grow more flower which then grow to produce more grains (Idwar and Haryanto 2015).

There is a tendency that under high density plantings the amount of grain decreases. This is because of competition between one plant and another so that optimal growth is not achieved. Another thing that happens if the population increases per unit area is the occurrence of competition for the absorption of nutrients and sunlight thereby reducing the efficiency of photosynthesis. The intensity of sunlight during plant growth greatly influences the formation and filling of grains (Fagi and De Datta 1989).

The need for nutrients for plant growth is fulfilled so that the results of photosynthesis were not only used for growth but were also stored and used as food reserves in the form of carbohydrates for the formation of flowers fruits and seeds. the more food reserves stored the greater the possibility of grain formation in each panicle. In the opinion of Gardner et al. (1991) that genetic factors can affect the number of flowers that develop to form seeds.

Table 3. Soil analysis of initial soil and following addition of ameliorants after rice harvest.

Character	Initial soil	Dolomite	Raice Hull Ash	Areca Nut Fiber Ash
pH	5.49	5.22	4.55	4.48
C-organic (%)	9.06	12.22	12.93	13.32
Phosphorus (%)	15.00	7.13	5.17	5.60
Potassium (%)	1.33	0.74	0.83	1.27
Sodium	8.62	7.44	8.90	10.00
Aluminum	0.48	1.23	2.7	2.91
Hydrogen	0.37	0.28	0.46	0.40

The size of the formed seeds were determined by the quantity of carbohydrates that were stored as food reserves besides that it is also influenced by the moisture content in the seeds which will also increase and genetic factors (Rudi 2017). Soil acidity low nutrient availability iron poisoning and sulfate poisoning were some of the soil characteristics that often inhibit plant growth in acid sulfate soils. Water management soil management combined with the application of in situ organic matter and the use of adaptive varieties in a one-way water system can increase the productivity of acid sulfate soils (Fahmi et al. 2006)

Acid sulphate soils have several problems in terms of soil fertility including low soil pH and nutrient content (especially available P) high Fe and Aluminum content uncontrollable waterlogging (Purnomo et al. 2005) H_2S content and Mn which can reach toxic levels (Danriesse and Sukardi 1990). Acid sulfate soils rich in these materials if they experience oxidation due to drainage will produce Fe metal in amounts that reach very high toxicity and acidity (Shamshuddin et al. 2004).

The results of the initial soil analysis test before treatment applied showed that the soil used for the experiment have pH 5.49 C organic 9.06. Phosphorus (P) available 15.0 Potassium (K) 1.33. Sodium (Na) 8.62. Aluminum (Al) 0.48 and Hydrogen (H) 0.37. From the results of soil analysis tests after being given the Dolomite Lime treatment it was found that there was a decrease in pH to 5.22. This could be caused by waterlogging which had occurred 2 times during the planting period which resulted in an increase in the solubility of elements contributing to soil acidity such as Al and Fe. Organic C increased to 12.22. Available phosphorus (P) decreased to 7.13 Potassium (K) also decreased to 0.74. Sodium (Na) 7.44. Aluminum (Al) 1.23 and Hydrogen (H) 0.28. In the rice husk ash addition there was also a decrease in pH to 4.55 organic C increased to 12.93. Available phosphorus (P) 5.17 potassium (K) 0 83. Sodium (Na) 8.9. Aluminum (Al) 2.7 and Hydrogen (H) 0.46. After being given the areca nut fiber ash the pH also decreased to 4.48. C organic 13.32. Available phosphorus (P) 5.60 Potassium (K) 1.27. Sodium (Na) 10. Aluminum (Al) 2.91 and Hydrogen (H) 0.4.

Giving Ameliorant in the form of rice husk ash and areca fruit coir ash in this study proved to be able to increase several elements namely organic C and sodium but the pH indicator decreased because it could have been caused by the release of humic acid from the decomposition results of Ameliorant material marked by an increase in the elements Al and Hydrogen from the provision of two types of Ameliorant materials used (rice husk ash and areca nut coir ash).

Amelioration and fertilization were important components in improving soil conditions in tidal land especially acid sulphate land. Soil amelioration is intended so that the soil reaction becomes better and the available nutrients in the soil increase and the addition of external nutrients can be more effective in increasing plant growth and yield. Giving CaCO3 lime 1.3 tons/ha increases soil pH thereby increasing the growth and production of rice plants. Giving $CaCO_3$ had an effect on the variable plant height to 99.25 cm the total tillers were 77.50 tillers and the number of productive tillers was 49 tillers grain yield was

36.40 however $CaCO_3$ had no effect on the dry paddy grain weight variable dry milled grain weight and shrewd weight (Krisnawati and Cahyoadi 2019)

Giving dolomite besides being able to increase soil pH can also contribute Ca and Mg nutrients so that activity in photosynthesis will increase. The Mg element is part of the protoplast which is very important in the photosynthesis process (Gultom and Mardaleni 2014).

The Agricultural Research Institute for Acid Sulfate Tidal Swamps (Balittra) has prepared amelioration and fertilization recommendations for various commodities and typologies of acid sulfate tidal swamps based on the results of previous studies. For rice plants the recommended dose of Ameliorant is 1000 – 3000 per kg ha^{-1} with a Nitrogen (N) content of 67.5 – 135; phosphorus content (P_2O_3) 45 – 57; and the content of Potassium Oxide (K_2O) 50 – 75 with the need to add rhizobium as much as 15 g kg-1 seed (Balittra 2003)

The advantages that can be obtained from using Ameliorant include soil structure colloid surface area so that it can hold water and soil from erosion and is able to bind the elements N Ca K Mg (Nabihaty 2010).

CONCLUSION

Base on the vegetative phase of rice plants the local variety Karang Duku showed the best growth based on indicators of plant height and maximum number of tillers while the superior variety Inpara 9 showed the panicle length parameter. Karang Duku local rice showed the greatest number of productive tillers while the local Karya Low variety was superior for the number of grains per panicle and four varieties were obtained namely the varieties Kuatik Tinggi Kuatik Rendah Bujang Berinai and Inpara 9 produced the greatest grain yield. Addition of ameliorants including dolomite rice husk ash and areca nut fiber ash in this experiment reduced rice plant height maximum number of tillers number of productive tillers panicle length number of grains per panicle number of empty grains per panicle grain yield per plot.

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