Ilmu Pertanian (Agricultural Science)

http://journal.ugm.ac.id/jip

Vol. 6 No. 3 December, 2021: 163–174| DOI: doi.org/10.22146/ipas.62041

Effects of cropping system and varieties on the rice growth and yield in acid sulphate soils of tidal swampland

Izhar Khairullah[1*], Wahida Annisa[1], Herman Subagyo[2], and Hendri Sosiawan[3]

[1]Indonesian Swampland Agricultural Research Institute (ISARI)
Jl. Kebun Karet, Loktabat Utara PO BOX 31, Banjarbaru 70712, Kalimantan Selatan, Indonesia
[2]Assessment Institute for Agricultural Technology (AIAT) East Java
Jl. Raya Karangploso Km. 4 PO Box 188, Malang 65101, East Java, Indonesia
[3]Indonesian Agroclimate and Hydrology Research Institute (IAHRI)
Jl. Ir. H. Juanda No. 98, Bogor 16123, West Java, Indonesia
*Corresponding author: izhar.balittra@gmail.com

Article Info

Received : 08th December 2020
Revised : 20th May 2021
Accepted: 02nd September 2021

Keywords:
Hazton, Inpara 8, Inpari 32, jajar legowo, Margasari

Abstract

Swampland plays a critical function in agriculture, specifically in growing rice production. The study aimed to determine the effects of cropping systems and varieties on the rice growth and yield in acid sulfate soil of tidal swampland. The experiment was conducted in a potential acid sulphate soils in Kapuas Regency, Central Kalimantan Province. The experiment was arranged in a split plot design with three replications. The main plot consisted of three HYV's of rice, namely Inpara 8, Inpari 32, and Margasari. The subplot consisted of five cropping systems, namely, Jarwo 2:1A, Jarwo 2:1B, Jarwo 2:1C, Hazton, and Tegel. The plot size was 4 m x 5 m. The variables observed included initial soil properties, plant growth, and yield components. The jajar legowo cropping system in this study was not able to increase rice yields in acid sulphate soil. There was an interaction effect of cropping systems and varieties on the plant height and number of tillers at vegetative phase. At generative and pre-harvest phases, there was significant single effect of variety and cropping system in the planting height and number of tillers, respectively. Both cropping system and variety significantly affected the number of panicles per hill, while panicle length, grain per panicle and grain yield were only affected by variety. There was no significant effect of both factors on the number of filled grains per panicle. Inpara 8 variety achieved the highest grain yield, which was 6.78 ton.ha^{-1} or equivalent to 4.34 ton.ha^{-1} of 14 % water content.

INTRODUCTION

Swampland is important in increasing the production of agricultural commodities, including rice production. Tidal swampland is a huge land in Indonesia of about 20.14 million ha, in which 20.1 % or 6.70 million ha of it is acid sulphate soils. The tidal swampland that has been used for new agricultural extensification is 1.43 million ha (Haryono et al., 2013). The potential tidal swampland area available for lowland rice in Area for Other Land Use (APL), Convertible Production Forests (HPK), and Production Forests (HP) is around 2.07 million ha (Ritung et al., 2014).

The development of acid sulfate soils in tidal swampland to increase agricultural production has encountered several obstacles, such as soil acidity, high Fe, Al and Mn, and reduction of exchangeable bases. This can lead to the stress on rice plants and/or the emergence of iron toxicity problems. The analysis of the potential production of tidal swampland covering an area of 2.27 million ha, if land optimization is carried out by increasing productivity, extensification, and increasing planting intensity, resulted in a pro-

How to cite: Khairullah, I., Annisa W., Subagyo, H., and Sosiawan, H. (2021). Effects of cropping system and varieties on the rice growth and yield in acid sulphate soils of tidal swampland . *Ilmu Pertanian (Agricultural Science)*, 6(3), pp. 163–174.

ISSN 0126-4214 (print) ISSN 2527-7162 (online)

duction delta of around 2.70 million ton grains per year (Haryono et al., 2013).

In rice cultivation, several cropping systems are known, such as tegel, jajar legowo, and Hazton systems. The Hazton cropping system uses 25–30 days old seedlings after sowing with 20–30 seedlings per clump or hole, in which all of them are parent plants so that they can be harvested by about 10 days earlier (Balai Penelitian dan Pengembangan Pertanian, 2015). Jajar legowo system has 30 % more clumps per ha than the tegel cropping system. For example, tegel cropping system of 25 cm × 25 cm has a population of 160,000 clumps per ha, while jajar legowo (jarwo) 2:1 system of to 25 cm to 50 cm × 12.5 cm has a population of 213,333 clumps per ha. The jajar legowo cropping system has one empty row between two or more rows of rice plants. Karokaro et al. (2014) reported that to achieve target of rice production, Ministry of Agriculture had issued several recommendations to be applied by farmers corresponding to jajar legowo cropping system. The jajar legowo cropping system can increase plant population by applying proper plant spacing, as a result of enlarged number of clumps per area unit (Ikhwani et al., 2013).

Plant spacing is basically applied to give plants possibility for growing well with narrow competition of sunlight, water and nutrients. The proper spacing is important in optimally utilizing sunlight for the photosynthesis process. The jajar legowo cropping system makes all plants or additional of them become aspect plants. Side plants can get additional daylight for higher air circulation, and plants will get more nutrients than those in tegel cropping system. Turmuktini et al. (2012) reported that yield differences as affected by various spacing were not the same for different varieties. The increase number of clumps per area unit suggest the increase in the number of panicles despite the decreasing number of panicles per clump. This effort would be more effective in increasing rice yields than increasing the number of tillers per clump.

The use of one seedling per clump/planting hole will reduce the competition between plants, but the disadvantage is the need of replanting. Sauki et al. (2014) added that the use of two or three seedlings per planting hole did not require replanting if one seedling plant died, but individual productivity was low. One seedling per planting hole decreases the number of seedlings needed and the cost of seeds purchase, as well as reducing competition between plants per clump.

Several high yielding varieties of swamp rice (Inpara) showed differences in response to the cropping systems. The yield of rice cv. Inpara 1 and 4 in jarwo cropping system was higher than that in tegel cropping system , the varieties of Air Tenggulang, Banyuasin, Dendang, Inpara 2, Inpara 3, and Inpara 5 showed no significant differences in grain yield when planted in tegel and jarwo cropping systems (Ikhwani and Makarim, 2012). The research aimed to determine of the effect of cropping systems and varieties on the rice growth and yield in acid sulfate soils of the tidal swamplands.

MATERIALS AND METHODS

The research was carried out in a potential acid sulfate soils of the tidal swampland in Sidomulyo Village, Tamban Catur Regency, Kapuas Regency, Central Kalimantan Province (-3°10'32", 114°23'32") in dry season of 2017. Soil sampling was carried out at a depth of 0 cm to 20 cm to identify the soil properties. The research was arranged in a Split Plot Design consisting of three replications. Three high yielding varieties, namely Inpara 8, Inpari 32, and Margasari, were used as main plots, and five cropping systems were used as subplots, including (1) Jajar legowo (jarwo) 2:1A, with a plant spacing of 50 cm × 25 cm × 12.5 cm (213,333 clumps per ha), (2) Jajar legowo (jarwo) 2:1B, with a plant spacing of 35 cm × 20 cm × 12.5 cm (290,950 clumps per ha), (3) Jajar legowo (jarwo) 2:1C, with a plant spacing of 35 cm × 20 cm × 10 cm (363,636 clumps per ha), (4) Hazton system, with a plant spacing of 30 cm × 30 cm and 20–25 seedlings (30–35 days old) per clump (111,111 clumps per ha), and (5) Tegel system, with a plant spacing of 20 cm × 20 cm and one young seedling (10–12 days old) per clump (250,000 clumps per ha).

The size of each plot was 4 m × 5 m, resulting in a total of 45 experimental units. The soil preparation was done mechanically using a hand tractor until it was ready for planting. Dolomite (1 $ton.ha^{-1}$) was applied to the land two weeks before transplanting. The seeds were soaked for twenty-four hours before sowing and incubated for twenty-four hours after sowing. Nurseries were well maintained to get good seedlings. Prior to planting, the condition of the plots was made on a macro basis to facilitate the

Table 1. Soil properties of the experimental site

Variables (Unit)	Value	Remarks
Texture (%): Sand	3.08	
Silt	25.28	
Clay	71.64	
pH (H_2O)	5.35	Acid
pH (KCl)	5.22	
EC ($mS.cm^{-1}$)	0.050	Low
C_{org} (%)	15.26	Very high
Total N (%)	0.088	Very low
K_{exc} (cmol(+).kg^{-1})	0.713	High
Na_{exc} (cmol(+).kg^{-1})	0.522	Medium
Ca_{exc} (cmol(+).kg^{-1})	2.372	Low
Mg_{exc} (cmol(+).kg^{-1})	7.356	High
CEC (cmol(+).kg^{-1})	46.59	Very high
Bases saturation (%)	23.51	Low
Potential P (mg.100 g^{-1})	26.652	Medium
Potential K (mg.100 g^{-1})	14.828	Low
P Bray 1 (g.kg^{-1})	67.260	Very high
Fe (g.kg^{-1})	416.10	High

planting of seedlings. In jajar legowo cropping system, the seedlings were planted in plots with three seedlings per clump at 21 days after sowing (DAS). The transplanting system in this study was used because it was better than other systems such as direct seeding. According to Javaid et al. (2012), the transplanting approach had the largest number of tillers and panicles, largest number of spikelets per panicle and highest grain yield in comparison to direct seeding with the same unit area.

The plant spacing used was in accordance with the treatments. The basal fertilizers given were N, P, and K at a rate of 90 kg.ha^{-1} N, 60 P_2O_5 kg.ha^{-1}, 60 kg.ha^{-1} K_2O, respectively. Phosphor and potassium fertilizers were applied simultaneously when the plants were seven days old after planting, while N fertilizer was given twice, namely when the plants were seven days and at 30 days after planting (DAP), each half of N fertilizer. Replacement of the dead plants was carried out by replanting spare seedlings at 21 DAP. Pest and disease control was performed according to the intensity of their attack by using recommended insecticides, pesticides or fungicides. The weed control was carried out at 21 and 49 DAP by removing the growing weeds. Harvesting was carried out at ripening stage, indicated with dry panicle and droopy panicles, un-hulled and unbreakable grains, yellow upper leaves, and dry lower parts.

The variables observed included soil properties before planting, plant growth, yield components and grain yield. Observation of plant growth (plant height and number of tillers) was made during the vegetative (49 DAP), generative (84 DAP), and harvest phases (100 DAP). Plant growth was observed in 10 clumps per plot. The yield components observed included the number of panicles per clump, number of spikelets per panicle, and filled number of grains per panicle. The percentage of filled grains was calculated by comparing the number of fertile grains and total number of grains. Meanwhile, grain yield in ton per ha was obtained from the grains yield area in plots harvest (4 m × 5 m). The grain yield per plot was fixed at a moisture content of 14 %, which was then converted into ton per ha.

RESULTS AND DISCUSSION

Soil properties

The results of soil analysis are presented in Table 1, in which the soil pH is 5.35 considered acidic. Soil organic C content is very high (15.26 %), with low

EC (0.050 mS.cm^{-1}) and low base saturation (25.51 %). The content of dissolved Fe in the soil using the extractant NH_4OAc pH 4.8 is 416.1 ppm. Based on these characteristics, soil in this area has a potential for iron toxicity, which is associated with an excessive of Fe^{2+} in the soil. This can occur in many different soil types, in which common characteristics of the contaminated soils are high reduced Fe, low pH, low CEC, low exchangeable K content (Ottow et al., 1982), and possibly related to P and Zn deficiencies and H_2S toxicity (Kirk, 2004). Paddy rice soils has periodically changed between oxic and anoxic conditions. In water-saturated soils, oxygen is rapidly depleted due to the respiration of soil microorganisms and plant roots in wetlands (Prade et al., 1990). The ferro concentrations of 300 mg.kg^{-1} to 400 mg.kg^{-1} could cause toxicity of rice plants (Ikehashi and Ponnamperuma, 1978).

Plant growth performance

The height of the plant is one of the important aspects of plant growth. Based on Table 2, there was an interaction effect of the cropping systems and varieties on the vegetative phase. The highest plant height was observed in Margasari variety planted with Hazton cropping system (61.4 cm). On the other hand, the generative phase and before harvest were affected by varieties only. The cropping system didn't affect the plant height. Margasari variety had the highest plant height at generative phase and before harvest, which was 107.1 cm and 132.1 cm, respectively (Table 3 and Table 4). Sunlight enters the planting area with a spacing that is not too dense, which is beneficial for rice photosynthesis. Sunlight is absorbed by plants for photosynthesis and the formation of photosynthate for optimal grain filling (Supriyanto et al., 2010). Plant populations in one field produce higher plants (Aribawa, 2012) as they try to find more sunlight. Plants that grow well are able to absorb nutrients in large quantities.

Table 2. Plant height (cm) at vegetative phase (49 DAP) as affected by cropping systems and varieties treatment

Cropping system	Varieties			Average
	Inpara 8	Inpari 32	Margasari	
Jarwo 2:1A (50 cm × 25 cm × 12.5cm)	54.6 ab	51.1 ab	55.4 ab	53.7
Jarwo 2:1B (35 cm × 20 cm × 12.5 cm)	52.3 ab	53.7 ab	57.5 ab	54.5
Jarwo 2:1C (35 cm × 20 cm × 10 cm)	56.3 ab	46.9 b	57.5 ab	53.6
Hazton (30 cm × 30 cm)	54.7 ab	44.7 c	61.4 a	53.6
Tegel (30 cm × 30 cm)	57.9 ab	49.3 ab	53.9 ab	53.7
Average	55.1	49.2	57.1	(+)

Remarks: Means followed by the same letters are not significantly different according to LSD α= 5 %, (+) sign indicate significantly different interaction effects between treatments, DAP= Days after planting.

Table 3. Plant height (cm) in generative phase (84 DAP) as affected by cropping systems and varieties

Cropping system	Varieties			Average
	Inpara 8	Inpari 32	Margasari	
Jarwo 2:1A (50 cm × 25 cm × 12.5cm)	87.7	79.7	98.8	88.7 a
Jarwo 2:1B (35 cm × 20 cm × 12.5 cm)	98.4	83.6	109.0	97.0 a
Jarwo 2:1C (35 cm × 20 cm × 10 cm)	91.9	80.9	114.5	95.7 a
Hazton (30 cm × 30 cm)	91.1	77.1	114.3	94.2 a
Tegel (30 cm × 30 cm)	91.3	84.9	98.8	91.7 a
Average	92.1 b	81.2 c	107.1 a	(-)

Remarks: Means followed by the same letters in the same row or column are not significantly different according to LSD α= 5 %, (-) sign indicate no interaction between treatments, DAP= Days after planting.

Table 4. Plant height (cm) before harvest (120 DAP) as affected by cropping systems and varieties

Cropping system	Varieties			Average
	Inpara 8	Inpari 32	Margasari	
Jarwo 2:1A (50 cm × 25 cm × 12.5cm)	116.7	93.9	128.1	112.9 a
Jarwo 2:1B (35 cm × 20 cm × 12.5 cm)	113.9	93.9	134.7	114.2 a
Jarwo 2:1C (35 cm × 20 cm × 10 cm)	113.7	92.4	136.4	114.2 a
Hazton (30 cm × 30 cm)	109.4	89.9	138.1	112.5 a
Tegel (30 cm × 30 cm)	113.1	92.3	123.1	109.5 a
Average	113.4 b	92.5 c	132.1 a	(-)

Remarks: Means followed by the same letters in the same row or column are not significantly different according to LSD α= 5 %, (-) sign indicate no interaction between treatments, DAP= Days after planting.

The increase in plant growth and productivity depends on the availability of nutrients for photosynthesis in the soil. Research by Nurshanti (2008) showed that the growth of taller plants was faster at wider spacings because they absorbed more sunlight. At high densities, there will be competition for sunlight, CO2, nutrients and water absorption. The decrease in the quality of the light received is due to the dense canopy, which leads to an increase in the height of the plant (Muyasir, 2012).

In general, the use of sunlight can be optimized for photosynthesis using jajar legowo cropping system, which is an attempt to increase the yield of rice through environmental impacts (Mulyaningsih et al., 2008). According to a study by Ikhwani et al. (2013), good plant growth depends on the plant spacing, as it affects the absorption of sunlight, nutrients, and water for photosynthesis.

There was an interaction effect of the cropping systems and varieties on the number of tillers number at vegetative phase (Table 5). The largest number of tillers was observed in the combination treatment of Hazton × Inpara 8, Hazton × Inpara 32, and Hazton × Margasari, resulting in 26.1, 26.2, and 27.6 tillers, respectively. The same result was also found in the generative phase and before harvest. The result showed that the number of tillers was affected by cropping system only. The largest number of tiller was observed in Hazton cropping system in both phases, producing 33.6 and 34.1 tillers (Table 6 and Table 7). Research by Yetti and Ardian (2010) showed that maximal number of tillers were found in good variety planted in favorable environmental conditions. In addition, the spacing to absorb solar radiation, nutrients, and water determines the maximum number of tillers. The use of jarwo cropping system help the plants in optimal absorption of nutrients and water for photosynthesis. The pres-

Table 5. Number of tillers number per clump at vegetative phase (49 DAP) as affected by cropping systems and varieties

Cropping system	Varieties			Average
	Inpara 8	Inpari 32	Margasari	
Jarwo 2:1A (50 cm × 25 cm × 12.5cm)	10.4 ab	11.7 b	10.9 ab	11.0
Jarwo 2:1B (35 cm × 20 cm × 12.5 cm)	10.1 ab	11.3 ab	11.6 ab	11.0
Jarwo 2:1C (35 cm × 20 cm × 10 cm)	10.3 ab	12.4 ab	11.6 ab	11.4
Hazton (30 cm × 30 cm)	26.1 a	26.2 a	27.6 a	26.6
Tegel (30 cm × 30 cm)	8.9 c	9.1 ab	10.5 ab	9.5
Average	13.2	14.1	14.5	(+)

Remarks: Means followed by the same letters are not significantly different according to LSD α= 5 %, (+) sign indicate significantly different interaction effects between treatments, DAP= Days after planting.

Table 6. Number of tillers per clump at generative phase (84 DAP) as affected by cropping systems and varieties

Cropping system	Varieties			Average
	Inpara 8	Inpari 32	Margasari	
Jarwo 2:1A (50 cm × 25 cm × 12.5cm)	18.2	17.2	19.2	18.2 c
Jarwo 2:1B (35 cm × 20 cm × 12.5 cm)	18.1	17.2	18.8	18.0 c
Jarwo 2:1C (35 cm × 20 cm × 10 cm)	18.3	17.4	18.6	18.1 c
Hazton (30 cm × 30 cm)	33.9	31.7	35.3	33.6 a
Tegel (30 cm × 30 cm)	22.1	22.1	24.2	22.8 b
Average	22.1 a	21.1 a	23.2 a	(-)

Remarks: Means followed by the same letters in the same row or column are not significantly different according to LSD α= 5 %, (-) sign indicate no interaction between treatments, DAP= Days after planting.

Table 7. Number of tillers before harvest (120 DAP) of rice as affected by cropping systems and varieties

Cropping system	Varieties			Average
	Inpara 8	Inpari 32	Margasari	
Jarwo 2:1A (50 cm × 25 cm × 12.5cm)	18.9	17.5	19.2	18.5 c
Jarwo 2:1B (35 cm × 20 cm × 12.5 cm)	18.4	17.3	19.1	18.3 c
Jarwo 2:1C (35 cm × 20 cm × 10 cm)	18.5	18.0	18.9	18.4 c
Hazton (30 cm × 30 cm)	34.2	32.0	35.9	34.1 a
Tegel (30 cm × 30 cm)	22.2	22.4	24.7	23.1 b
Average	22.4 a	21.4 a	23.6 a	(-)

Remarks: Means followed by the same letters in the same row or column are not significantly different according to LSD α= 5 %, (-) sign indicate no interaction between treatments, DAP= Days after planting.

ence of white space in the jarwo cropping system will increase the plants' ability to retain light and CO_2.

The increase in the number of rice seedlings was due to the fact that young seedlings had better adaptability than the old ones (Hazton system) so that plants could grow better. A more adequate period of seedling adaptation to the new environment is resulted by faster seedling transfer. In addition, the formation of phyllochron is related to the number of rice tillers. Phyllochron is a set of stems, leaves and roots sprouting out of the stump and germinate. The number of tillers formed increases as the older seedlings are transferred to the field, and fewer phyllochrones are formed. Meanwhile, when young seedlings are transferred to the field, more phyllochrones are formed (Sunadi, 2008).

Increased number of seedlings per clump leads to the increased competition between plants grown in the same clump for sunlight, water and nutrients, affecting rice growth and grain yield. According to Syaiful et al. (2012), using a seedling per clump would strengthen the roots because there was not too much competition. Cropping system as a cultivation technology component affects yield and income of rice. The spacing between plants in the field affects six important processes, such as solar radiation and nutrients uptake, plant water requirements, CO_2 and O_2 circulation, free space, and canopy climate (Makarim et al., 2005). The results of the study by Pratiwi et al. (2010) showed that wide planting spacing provided opportunities for plant varieties to demonstrate their growth potential. Higher planting density results in fewer number of tillers and long panicles per clump. In small populations (wide spacing), the diversity of the rice clump is great, but the grain area and yield components are smaller compared to those with narrower spacing.

Sohel et al. (2009) stated that optimal spacing helped the plant grow well. The number of tillers will be maximal if the plants have good characteristics accompanied with favorable environmental conditions. According to Hatta (2011), maximum number of tillers is determined by spacing, as it determines solar radiation, nutrients, and plant growth. The competition for sunlight and nutrients in wide spacing was less compared to that in the narrow spacing.

Research by Rahimi et al. (2011) found that spacing significantly affected the number of productive tillers, reporting that a spacing of 30 cm × 30 cm produced 15.53 productive tillers , while a spacing of 20 cm × 20 cm produced 9.06 tillers. The efficient use of nutrients and the sufficient amount of light and water increase the number tillers in transplanted crop (Awan et al., 2011). The maximum number of tillers per unit area was negatively correlated with plant density (Sasaki et al., 1999). Large number of seeds probably results in a minimum number of tillers because plant cannot use the available resources efficiently as a result of high competition during the nutrient uptake. According to Hatta (2012), the proper spacing will result in optimum growth, large number of tillers and high yields, in addition to the effect of spacing on the potential yield per hectare.

It is reported that the wide spacing between plants does not affect the grain yield per unit area, but improves the ability of the plant canopy to absorb solar, thereby increasing the yield, soil volume, total length of the roots, dry weight of the plant, and the weight of the grains (Kurniasih et al., 2008; Lin et al., 2009; Hatta, 2012). Rahimi (2011) stated that the mean seed weight was largely determined by the seeds shape and size.

Yield and yield component

The component of grain yield, including the number of panicles per clump, number of spikelets per panicle, and percentage of filled grains are pre-

Table 8. Number of panicles per clump as affected by cropping systems and varieties

Cropping system	Varieties			Average
	Inpara 8	Inpari 32	Margasari	
Jarwo 2:1A (50 cm × 25 cm × 12.5cm)	17.8	17.1	18.6	17.8 c
Jarwo 2:1B (35 cm × 20 cm × 12.5 cm)	17.9	17.2	19.0	18.0 bc
Jarwo 2:1C (35 cm × 20 cm × 10 cm)	17.8	17.1	18.8	17.9 bc
Hazton (30 cm × 30 cm)	34.3	32.5	33.3	33.4 a
Tegel (30 cm × 30 cm)	21.6	19.9	23.3	21.6 b
Average	21.9 b	20.8 b	22.6 a	(-)

Remarks: Means followed by the same letters in the same row or column are not significantly different according to LSD α= 5 %, (-) sign indicate no interaction between treatments, DAP= Days after planting.

Table 9. Panicle length (cm) of rice as affected by cropping systems and varieties

Cropping system	Varieties			Average
	Inpara 8	Inpari 32	Margasari	
Jarwo 2:1A (50 cm × 25 cm × 12.5cm)	23.4	21.1	22.5	22.3 a
Jarwo 2:1B (35 cm × 20 cm × 12.5 cm)	22.2	21.9	22.2	22.1 a
Jarwo 2:1C (35 cm × 20 cm × 10 cm)	22.1	21.1	22.0	21.7 a
Hazton (30 cm × 30 cm)	22.5	20.9	20.7	21.4 a
Tegel (30 cm × 30 cm)	22.5	22.1	21.5	22.0 a
Average	22.5 a	21.4 b	21.8 b	(-)

Remarks: Means followed by the same letters in the same row or column are not significantly different according to LSD α= 5 %, (-) sign indicate no interaction between treatments, DAP= Days after planting.

sented in Table 8 to Table 12. Based on Table 8, there was no interaction effect of both factors on the number of panicles. Hazton cropping system and Margasari variety resulted in the highest number of panicles per clump, which was 33.4 and 22.6, respectively. According to Table 9, the panicle length was affected by variety only, in which Inpara 8 variety gave the highest value (22.5 cm). The number of spikelets was affected by variety but not affected by cropping system, in which Inpara 8 had the largest number of spikelets (144.5) (Table 10). On the other hand, the percentage of filled grains was

Table 10. Number of spikelets per panicle as affected by cropping systems and varieties

Cropping system	Varieties			Average
	Inpara 8	Inpari 32	Margasari	
Jarwo 2:1A (50 cm × 25 cm × 12.5cm)	147.7	142.7	125.9	138.8 a
Jarwo 2:1B (35 cm × 20 cm × 12.5 cm)	147.1	142.5	126.0	138.5 a
Jarwo 2:1C (35 cm × 20 cm × 10 cm)	148.1	142.6	126.2	139.0 a
Hazton (30 cm × 30 cm)	128.1	139.3	91.2	119.5 a
Tegel (30 cm × 30 cm)	151.4	144.6	128.4	141.5 a
Average	144.5 a	142.4 ab	119.5 b	(-)

Remarks: Means followed by the same letters in the same row or column are not significantly different according to LSD α= 5 %, (-) sign indicate no interaction between treatments, DAP= Days after planting.

Table 11. Filled grains percentage per panicle of rice as affected by cropping systems and varieties

Cropping system	Varieties			Average
	Inpara 8	Inpari 32	Margasari	
Jarwo 2:1A (50 cm × 25 cm × 12.5cm)	78.9	59.5	83.5	74.0 a
Jarwo 2:1B (35 cm × 20 cm × 12.5 cm)	81.7	65.6	85.3	77.5 a
Jarwo 2:1C (35 cm × 20 cm × 10 cm)	88.1	63.9	87.4	79.8 a
Hazton (30 cm × 30 cm)	68.5	59.8	83.2	70.5 a
Tegel (30 cm × 30 cm)	79.2	68.9	84.5	77.6 a
Average	79.3 a	63.5 a	84.8 a	(-)

Remarks: Means followed by the same letters in the same row or column are not significantly different according to LSD α= 5 %, (-) sign indicate no interaction between treatments, DAP= Days after planting.

Table 12. Grain yield (ton.ha^{-1}) of rice as affected by cropping systems and varieties

Cropping system	Varieties			Average
	Inpara 8	Inpari 32	Margasari	
Jarwo 2:1A (50 cm × 25 cm × 12.5cm)	6.02	5.22	4.13	5.12 a
Jarwo 2:1B (35 cm × 20 cm × 12.5 cm)	6.12	5.50	4.30	5.31 a
Jarwo 2:1C (35 cm × 20 cm × 10 cm)	6.78	6.03	5.05	5.96 a
Hazton (30 cm × 30 cm)	5.35	4.78	3.95	4.69 a
Tegel (30 cm × 30 cm)	4.68	4.50	3.73	4.31 a
Average	5.79 a	5.21 ab	4.23 b	(-)

Remarks: Means followed by the same letters in the same row or column are not significantly different according to LSD α= 5 %, (-) sign indicate no interaction between treatments, DAP= Days after planting.

not affected by cropping systems (70 % to 77 %) and varieties (63 % to 84 %) (Table 11). This may be due to the large number of seedlings, which are old, so that the fertility of grains was not optimal.

High availability of nutrients has increased the production of tillers per unit area, resulting a maximum number of panicles (Aslam et al., 2008). Fewer tillers result in fewer panicles because the supply of nutrients to the tillers is the same due to large space, sunlight and aeration. Moreover, less competition between germinating seeds results in the maximum number of panicles per unit area (Baloch et al., 2000). A decrease in the number of panicles per clump significantly increases the number of panicles per m^2 (Mobasser et al., 2009). Phenolic acid ranging from 260 ppm (IR64 variety) to 777 ppm (Merning variety) have been tested on 10 varieties for their ability to inhibit plant growth on solid seeding, including residues left for planting (Rauf et al., 2005). This phenomenon occurs possibly be because the transplanted rice plants utilize the environmental conditions more efficiently than the rice plants with direct seedling. Therefore, the production of spikelets per panicle in transplanted rice plants was better than that in direct seedling (Yang et al., 1998). During the panicle growth period, the best availability and utilization of nutrients was found in transplanting plants that were replanted at appropriate intervals (Awan et al., 2011). Direct seeding was proven to produce smaller number of spikelets per panicle (Hayashi et al., 2007).

Grain yields were affected by varieties only, in which Inpara 8 variety had the highest yield, which was 5.79 ton.ha^{-1} (Table 12). A wide spacing would increase the capture of solar radiation by plant canopy, thereby increasing the number of productive tillers, volume and total root length, plant dry weight, and grain weight per clump, but it had no effect on yield per unit area (Kurniasih et al., 2008, Lin et al., 2009, Hatta, 2012). On the other hand, a decrease in the number of panicles per clump increased the number of panicles per clump per m^2 (Mobasser et al., 2009). The results of experiment by Kumalasari et al. (2017) showed that the spacing of 30 cm × 30 cm and one seed per hole produced 9.92 ton.ha^{-1} of hybrid rice PP3 variety. Experiment by Muyassir (2012) stated that the spacing had a significant effect on the yield, and the best was 30 cm × 30 cm with grain yields reaching 8.12 ton.ha^{-1}. Christanto and Agung (2014) stated that the high rice yield plant area unity was not significantly supported by plant vegetative growth such as the maximum number of tillers and the number of productive tillers. According to Pinem et al. (2013), that at different spacing, the grain weight per panicle and 1,000 grain weight were not significantly different. The other research by Paulina et al. (2020) showed that there was not interaction effect of plant spacing and jajar legowo cropping systems on the grain yield in lowland rice.

Wu et al. (1999) add that the types of Javanica rice and brown rice have high allelo chemical compounds so that they are not suitable for dense planting. At dense cropping system, including Jarwo cropping system, there was intensive competition for plant roots to absorb water and nutrients. Therefore, rice varieties that are drought tolerant or adaptive to soils with low fertility have the potential to produce higher grain in the Jarwo planting method compared to Tegel method. Rice varieties that are relatively drought tolerant can be identified quickly based on the root penetration test to the wax layer. These varieties include Gajah Mungkur, Towuti and IR64 (Lestari et al., 2005, Suardi and Moeljopawiro, 1999). Jajar legowo (Jarwo) cropping system has a higher chance of producing grain because more photosynthesis occurs, and the plants are more effective in absorbing sunlight and diffusion of CO_2. Lin et al. (2009) stated that a wide spacing could improve the total light absorbed by plants, thereby increasing the grain yield. The higher population in Jarwo cropping system provides an opportunity for high yields. Variety performance at wide spacing of 40 cm × 40 cm is different compared to dense spacing, especially in the number of panicles (Suhartatik et al., 2011). The use of empty space in the jajar legowo system leads to effective photosynthesis process at generative phase, resulting in the more photosynthates carried to seeds so that the grain yield are higher (Irmayanti, 2011).

CONCLUSIONS

The jajar legowo cropping system in this study was not able to increase rice yields in acid sulfate soil. There was an interaction effect of the cropping systems and varieties on the plant height and number of tillers at vegetative phase. At generative and near-harvest phases, there was only a single variety effect on the plant height and cropping system effect on the number of tillers. There was cropping system and varieties effect on the number of panicles per clump, while panicle length, grain per panicle and grain yield were only affected by varieties. There was no interaction effect and/or single factor effect on the number of filled grains per panicle. Inpara 8 variety showed the highest grain yield, which was 6.78 ton.ha^{-1} or equivalent to 4.34 ton.ha^{-1} of 14 % water content.

ACKNOWLEDGMENTS

This study was funded by the 2017 Indonesian National Budget for the Indonesian Swampland Agricultural Research Institute, IAARD. Thank for M. Nadlir who has dedicated his time and persistence in collecting the experiment data.

REFERENCES

Aribawa, I.B. (2012). Pengaruh sistem tanam terhadap peningkatan produktivitas padi di lahan sawah dataran tinggi beriklim basah. *Seminar Nasional Kedaulatan Pangan dan Energi, Fakultas Pertanian, Universitas Trunojoyo*.

Aslam, M., Hussain, S., Ramzan, M., and Akhter, M. (2008). Effect of different stand establishment techniques on rice yields and its attributes. *J. Anim. Pl. Sci.*, 18(2–3), pp. 80–82.

Awan T.H., Ali, R.I., Manzoor, Z., Ahmad, M., and Akhtar, M. (2011). Effect of different nitrogen levels and row spacing on the performance of newly evolved medium grain rice variety, KSK-133. *J. Anim. Pl. Sci*., 21(2), pp. 231–234.

Balai Penelitian dan Pengembangan Pertanian. (2015). *Panduan teknologi budidaya hazton pada tanaman padi*. 1st ed. Jakarta: Badan Penelitian dan Pengembangan Pertanian, Kementerian Pertanian, pp. 20.

Baloch, M.S., Awan, I.U., Jatoi, S.A., Hussain, I., and Khan, B. (2000). Evaluation of seeding densities in broadcast wet seeded rice. *J. Pure and Applied Sci*., 19(1), pp. 63–65.

Christanto, H. and Agung, I.G.A.M.S. (2014). Jumlah bibit per lubang dan jarak tanam berpengaruh terhadap hasil padi gogo (*Oryza sativa* L.) dengan system of rice intensification di lahan kering. *J. Bumi Lestari*, 14(11), pp. 1–8.

Haryono, Noor, M., Syahbuddin, H., Sarwani, M. (2013). *Lahan rawa: penelitian dan pengembangan*. 2nd ed. Jakarta: IAARD Press, pp.103

Hatta, M. (2011). Pengaruh tipe jarak tanam terhadap anakan, komponen hasil, dan hasil dua varietas padi pada metode SRI. *J. Floratek*, 6(2), pp. 104-113.

Hatta, M. (2012). Jarak tanam sistem legowo terhadap pertumbuhan dan hasil beberapa varietas padi pada metode SRI. *Jurnal Agrista*, 16(2), pp. 87–93.

Hayashi S., Kamoshita, A., Yamagishi, J., Kotchasatit, A., and Jongdee, B. (2007). Genotypic differences in grain yield of transplanted and direct-seeded rainfed lowland rice (*Oryza sativa* L.) in northeastern Thailand. *Field Crop Res*., 102(1), pp. 9–21.

Ikehashi, H and F. N. Ponnamperuma. (1978). *Varieties tolerance of rice for adverse soils: Soil and Rice*. Los Banos, Philippines: International Rice Experiment Institute, pp. 801–823.

Ikhwani and A.K. Makarim. 2012. Respons varietas padi terhadap perendaman, pemupukan dan jarak tanam. *J. Pen. Pert. Tan. Pangan*, 31(2), pp. 93–99.

Ikhwani, Pratiwi, G.R., Paturrahman, E., and Makarim, A.K. (2013). Peningkatan produktivitas padi melalui penerapan jarak tanam jajar legowo. Iptek Tanaman Pangan, 8(2), pp. 72–79.

Irmayanti, A. (2011). *Respons beberapa varietas padi terhadap dua sistem tanam*. Thesis. Tadulako University.

Javaid, T., Awan, I.U., Baloch, M.S., Shah, I.H., Nadim, M.A., Khan, E.A., Khakwani, A.A., and Abuzar, M.R. (2012). Effect of planting methods on the growth and yield of coarse rice. *Journal of Animal & Plant Sciences*, 22(2), pp. 358–362.

Karokaro, S., Rogi, J.E.X., Runtunuwu, D.S., and Tumewu, P. (2015). Pengaturan jarak tanam padi (*Oryza sativa* L.) pada sistem tanam jajar legowo. *Cocos*, 6(16),pp. 1–7.

Kirk, G. (2004). *The biogeochemistry of submerged soils*. 1st ed. Chichester, UK: John Wiley and Sons, pp. 291.

Kumalasari, S.N., Sudiarso, and Suryanto, A. (2017). Pengaruh jarak tanam dan jumlah bibit pada tanaman padi (*Oryza sativa* L) hibrida varietas PP3. *Jurnal Produksi Tanaman*, 5(7), pp. 1220–1227.

Kurniasih, B., Fatimah, S., and Purnawati, D.A. (2008). Karakteristik perakaran tanaman padi sawah IR64 (*Oryza sativa* L.) pada umur bibit dan jarak tanam yang berbeda. *Ilmu Pertanian (Agricultural Science)*, 15(1), pp. 15–25.

Lestari, E.G., Guharja, E., Harran, S., and Mariska, I.

(2005). Uji daya tembus akar untuk seleksi somaklon toleran kekeringan pada padi varietas Gajah Mungkur, Towuti dan IR64. *Penelitian Pertanian Tanaman Pangan*, 24(2), pp. 97–103.

Lin, X.Q., Zhu, D.F., Chen, H.Z., and Zhang, Y.P. (2009). Effects of plant density and nitrogen application rate on grain yield and nitrogen uptake of super hybrid rice. *Rice Science*, 16(2), pp. 138–142.

Makarim, A.K., Pasaribu, D., Zaini, Z. and Las, I. (2005). *Analisis dan sintesis pengembangan model pengelolaan tanaman terpadu padi sawah*. Jakarta: Balai Penelitian Tanaman Padi, pp. 18.

Mobasser, H.R., Yadi, R., Azizi, M., Ghanbari, A.M., and Samdalari, M. (2009). Effect of density on morphological characteristics related-lodging on yield and yield components in varieties rice (*Oryza sativa* L.) in Iran. *American-Eurasian Journal of Agriculture and Environmental Science*, 5(6), pp. 745–754.

Mulyaningsih. (2008). *Perbandingan analisis pendapatan SRI (System of Rice Intensification) dengan system konvensional*. Undergraduated Thesis. Lampung University.

Muyassir. (2012). Efek jarak tanam, umur, dan jumlah bibit terhadap hasil padi sawah (*Oryza sativa* L.). *Jurnal Manajemen Sumberdaya Lahan*, 1(2), pp. 207–212.

Nurshanti, R. (2008). *Pengaruh umur bibit dan jarak tanam terhadap pertumbuhan dan produktivitas Tanaman Buru Hotong* (*Setaria italica* (L.) Beauv.). Undergraduated Thesis. IPB University.

Ottow, J.C.G., Benckiser, G., and Watanabe, I. (1982). Iron toxicity of rice as a multiple nutrition soil stress. T*ropical Agriculture Research Series : Proceedings of a Symposium on Tropical Agriculture Researches*, pp. 167–179.

Paulina U., Syarif, A., and Anwar, A. (2020). Strategy for development of rice sawah culture planting in jarwo plants with various modification of plant distance. *International Journal of Environment, Agriculture and Biotechnology*, 5(1), pp. 174–180.

Pinem, A.H., Barus, A., and Hanum, C. (2013). Efektifitas jarak tanam dan jumlah benih per lubang tanam terhadap pertumbuhan dan produksi padi gogo. *J. Online Agroekoteknologi*, 1(4), pp. 921–929.

Prade, K., Ottow, J. C. G., Jacq, V., Malouf, G., and Loyer, J.Y. (1990). *Relationships between the properties of flooded rice soils and iron toxicity in Lower Casamance (Senegal). Studies, review and summary of previous work*. Cashiers ORSTOM, serie Pedologie. Montpellier, France: IRD, pp. 453–474.

Pratiwi, G.R., Suhartatik, E., and Makarim, A.K. (2010). Produktivitas dan komponen hasil tanaman padi sebagai fungsi dari populasi tanaman. In: Abdulrachman, S. et al. (eds.). *Inovasi Teknologi Padi untuk Mempertahankan Swasembada dan Mendorong Ekspor Beras*. Prosiding Seminar nasional Hasil Penelitian Padi 2009. 2nd ed. Jakarta: Balai Besar Penelitian Tanaman Padi. pp.443–450.

Rahimi, Z., Zuhry, E., and Nurbaiti. (2011). *Pengaruh jarak tanam terhadap pertumbuhan dan produksi padi sawah (Oryza sativa* L.*) varietas Batang Piaman dengan Metode SRI di Padang Marpoyan*. [online]. Available at: https://repository.unri.ac.id/xmlui/bitstream/handle/123456789/1608/JURNAL%20ZUHDI%20RAHIMI.pdf?sequence=1&isAllowed=y. [Accessed 07 Dec 2020).

Rauf, A.W., Tohari, Yudono, P., and Kabirun, S. (2005). Pengaruh alelopati padi terhadap pertumbuhan dan hasil kedelai pada sistem tanam berurutan padi kedelai. *Penelitian Pertanian Tanaman Pangan*, 24(2), pp. 76–84.

Ritung, S., Suryani, E., Subardja, D., Sukarman, Nugroho, K., Suparto, Hikmatullah, Mulyani, A., Tafakresnanto, C., Sulaeman, Y., Subandiono, R.E., Wahyunto, Ponidi, Prasodjo, N., Suryana, U., Hidayat, H., Priyono, A., and Supriatna, W. (2014). *Sumberdaya lahan pertanian Indonesia: luas, penyebaran, dan potensi ketersediaan*. Jakarta: IAARD Press, pp. 100.

Sasaki, R., Yamaguchi, H., and Matsuba, K. (1999). Theoretical analysis of the tillering capacity for the lower density of seedling establishment in direct seeding cultivation of rice (*Oryza sativa* L.). *Japanese Journal of Crop Science*, 68(1), pp. 10–15.

Sauki, A., Nugroho, A., and Soelistyono, R. (2014). Pengaruh jarak tanam dan waktu penggenangan pada metode SRI (System of Rice Intensification) terhadap pertumbuhan dan hasil tanaman padi (*Oryza sativa* L.). Jurnal Produksi Tanaman, 2(3),pp. 121–127.

Sohel, M.A.T., Siddique, M.A.B., Asaduzzaman, M., Alam, M.N., and Karim, M.M. (2009). Varietal performance of transplant aman rice under different hill densities. *Bangladesh J. Agric. Res*., 34(1), pp. 33–39.

Suardi, D. and Moeljopawiro, S. (1999). Daya tembus akar sebagai kriteria seleksi ketahanan kekeringan pada padi: I. Pengaruh tingkat kekerasan dan ketebalan lapisan media campuran paraffin dan vaselin terhadap daya tembus akar. *Penelitian Pertanian Tanaman Pangan,* 18(1), pp. 29–34.

Suhartatik, E., Makarim, A.K., and Ikhwani. (2011). Respon lima varietas unggul baru terhadap perubahan jarak tanam. *Prosiding Seminar Nasional Hasil Penelitian Padi 2011 Inovasi Tekonologi Padi Mengantisipasi Cekaman Lingkungan Biotik dan Abiotik*, pp. 1259–1273.

Sunadi. (2008). *Modifikasi paket teknologi SRI (System of Rice Intensification) untuk meningkatan hasil padi sawah (Oryza sativa* L.*).* Dissertation. Andalas University.

Supriyanto, E.A, Syakiroh, J., and Wisnu, A. (2010). Pengaruh system tanam legowo dan konsentrasi pupuk pelengkap cair terhadap pertumbuhan dan produksi padi. B*iofarm Jurnal Ilmiah Pertanian*, 13(8).

Syaiful, S.A., Sennang, N.S., and Yasin, M. (2012). Pertumbuhan dan produksi padi hibrida pada pemberian pupuk hayati dan jumlah bibit per lubang tanam. *J. Agrivigor*, 11(2), pp. 202–213.

Turmuktini, T., Widodo, W., and Kanta. (2012). Karakterisasi pertumbuhan dan hasil beberapa varietas padi akibat pengaturan jarak tanam yang berbeda di lahan sawah irigasi. *CEFARS Jurnal Agribisnis dan Pengembangan Wilayah*, 3(2), pp. 19–26.

Wu, H., Pratley, J., Leemerle, D., and Haig, T. (1999). Crop cultivars with allelopathic capability. *Weed Research*, 39, pp. 171–180.

Yang, S., Sang, Y.U., Tae, P.S., and Tae, C.B. (1998). Physical and yield responses of rice cultivars in direct seeded and transplanted rice cultivation. *J. Crop Sci*., 40(2), pp. 109–47.

Yetti, H. and Ardian. (2010). Pengaruh penggunaan jarak tanam terhadap pertumbuhan dan produksi padi sawah (*Oryza sativa* L.) varietas IR dengan metode SRI (*System of Rice Intensification*). *Sagu*, 9(1), pp. 1–27.