The impact of water management systems and biofertilizers on soybean production in type B tidal swamp lands in Kapuas district, Central Kalimantan, Indonesia

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ABSTRACT

Acid sulfate land is a land resource that can be optimized to achieve soybean self-sufficiency. Management of irrigation systems and the use of biological fertilizers play an important role in efforts to increase yields. This research aimed to determine the effect of biological fertilizer application and water management systems on soybean yields on tidal swamp land of overflow type B. The research was carried out on potential acid sulphate land of overflow type B using a Split Plot Design with the main plot, namely water management, namely the system management with trenches 20 cm deep and without trenches and subplots is the use of biological fertilizer, namely, Rhizobium sp., Mycorrhiza, Rhizobium sp. specific for acid land, Rhizobium sp. + Mycorrhiza. Management of water level without channels and without the addition of biological fertilizer for cultivating soybean plants in the dry season on type B tidal land is effective in maintaining soil pH that can be tolerated by soybean plants. There was no interaction and no significant effect of regulating the water level with ditches and adding biological fertilizer on the productivity of soybean plants due to rising water levels.
Keywords: acid sulfate soil, biofertilizer, soybean, water management, tidal swamp

INTRODUCTION

Soybean is a functional food source in terms of nutritional value and health benefits. It is undeniable that the need for soybeans both as food and animal feed in Indonesia cannot be fulfilled. According to Simatupang et al. (2003) [1], this is evidenced by the number of soybean deficits that continue and tend to continue to increase if there are no breakthrough efforts to increase production and in the end Indonesia will depend on imports to cover the deficit. According to the Ministry of Agriculture (2016) [2], Indonesia's soybean production has not been able to meet the demand for soybean consumption even though soybean consumption tends to decrease and Indonesian soybean production tends to increase. Based on the performance of soybean export and import values for the period 1980 to 2015, the trade balance Indonesian soybean during this period experienced an increasing deficit which tended to continue to increase. It was also found that the decrease in soybean harvested area in Java was due to the conversion of agricultural land to non-agricultural activities.

Based on the results of the mapping of the Center for Agricultural Land Resources (BBSDLP), the area of swamp land throughout Indonesia is around 33.43 million ha and the area of land suitable for agricultural activities is 9.53 million ha. Until now, only 23.8% of the total area of swamp land that is suitable for agricultural activities, namely 71.2%, has not been utilized.

Acid sulphate land is a land resource that can be optimized to achieve self-sufficiency

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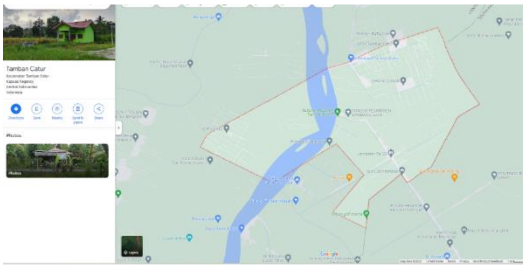
in soybeans but swampland has unique characteristics. The soil reaction is classified as slightly acidic to extraordinarily acidic. The values range from pH 4 (Sulfaquents) to pH < 3.4 (Sulfaquepts) (Kochian et al., 2004) [3]. This will cause toxic elements (Notohadiprawiro, 2000) [4]. Many pyrite minerals ($Fe(S_2)$ are also found in tidal lands which contain large amounts of iron which, when the pyrite layer is oxidized, can lower the pH to ≤ 3.5 (Muhrizal et al., 2006) [5]. The characteristics of the swamp land will certainly be a limiting factor for plants.

According to Seenivasagan et al. (2021) [6], the use of biological fertilizers has no dangers or side effects. Utilization of biological fertilizers is expected to help overcome problems in swamp land.

The problem in soybean cultivation in tidal swamp land is that soybean plants cannot stand flooded soil conditions. Proper management needs to be done. Water management is not only necessary to control water during high tide, but also to maintain the water level during the dry season so that the pyrite layer does not oxidize. In a study by Shamshuddin et al. (2000) [7], if oxidation occurs, drainage water in acid sulfate soils will bring oxidation and reduction products such as H^+ ions, $(SO)_4^{2-}$, $(Al)^{3+}$, and ($Fe)^{2+}$, as well as nutrients $(Ca)^{2+}$, $(Mg)^{2+}$, and K^+. Micro elements such as Al and Fe are available in large quantities so that they can harm plants. This study aims to 1) determine the effect of water management and application of biological fertilizers on the productivity of soybean plants in tidal swamps with overflow type B.

MATERIALS AND METHODS

The research was conducted in Sidomulyo Village, Tamban Catur District, Kapuas Regency, Central Kalimantan (*(3º 20'66 SL and 114º ' 40'54 EL)*



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The research was conducted using a Split Plot Design with the Main Plot namely water management: **1.** Control (Without adjusting the water level) (P0), 2. Water level 20cm (water depth in the quarter ditch 20 cm below ground level (P1). Subplots are the use of biological fertilizers : A.Control (A1), B. Rhizobium sp. sp. (A2), C. Mycorrhiza (A3), D. Rhizobium sp. sp. acid soil specific (A4), and E. Rhizobium sp. sp. + Mycorrhiza (A5)

Table 1. Treatment Combinations

Treatments	A1	A2	A3	A4	A5
P0	P0A1	P0A2	P0A3	P0A4	P0A5
P1	P1A1	P1A2	P1A3	P1A4	P1A5

Seed preparation was carried out by preparing soybean seeds of anjasmoro, mycorrhiza, Rhizobium, and Rhizobium specific sour varieties. The agronomic parameters observed were periodic plant height (2 weeks), yield components (number of pods), dry seed yield (tiles). Plant height observations were carried out every 2 weeks on 10 sample plants in one treatment plot with a total sample of 300 plants. Observation of the yield component was carried out by weighing the dry seed yield from the tile plots in each treatment plot. Soil analysis was carried out at 30 days after planting (dap). Soil data components observed included: The degree of acidity (pH), redox potential (Eh), and electrical conductivity (EC) were directly measured in the field before application and once every 2 weeks with the Tester 35 Series, Available P was observed at 30, 60, and 90 dap using the Bray-I method, organic-C with the Walkley & Black method observed at 30, 60, and 90 dap, total- N with the Kjehdal N method were observed at 30, 60 and 90 dap, exchangeable-K, using the NH_4OAc 1 N method was observed at 30, 60 and 90 dap (Soil Research Institute, 2009) . Experimental water management observations include:

a. Observation of ground water level. Measurement using a perforated pipe then buried into the ground. b. The degree of acidity (pH) and electrical conductivity (EC) are directly measured in water with the 35 Series Tester.

Data analysis

Experimental data were analyzed using variance (ANOVA) to determine whether there was a treatment that had a significant difference. If the effect is significantly different (F Count > F Table, α 5%) then proceed with further tests to find out the treatment is significantly different. This analysis uses the software SAS 9.10 for windows.

RESULTS AND DISCUSSION

Water Level

Based on a 1: 100,000 scale semi-detailed soil map, the study location is a tidal land with overflow types B to C (Subagyono et al, 1999) (Subagio, 2006 [9] and has a sulfidic layer at a depth of more than 50 cm so that the research location is classified as a potential acid sulphate land. The water level is a factor that needs to be considered in conducting agricultural cultivation in tidal swamps, especially on acid sulphate soils. This is because the water level affects the redox conditions, the pyrite layer will be oxidized to acid sulphate which can further reduce the pH value to 4 due to pulverization until it reaches the pyrite layer (Dent & Pons, 1995) [10].

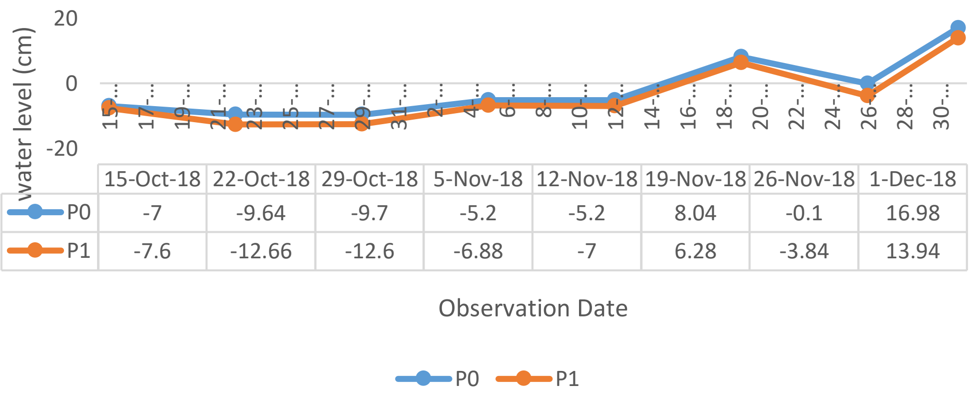
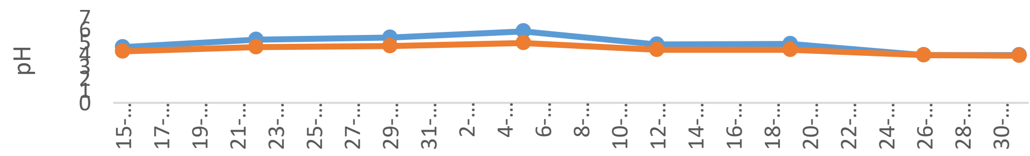


Figure 1. Fluctuations in water level , P0: No water inlet
P1: 20 cm channel

Figure 1 shows the fluctuation of the groundwater level at the study site. A negative value indicates that the water table is below the ground surface and a positive value indicates that the water table has exceeded the ground level. The water level during the planting period fluctuated. Water fluctuations on land are influenced by tidal activity. According to Haryono et. al. (2013) [11], river flow affects the groundwater table due to the gravitational force or the gravitational pull of the earth and moon in the solar system. The farther the river flows from the estuary, the weaker the river flows. According to Suriadikarta (2005) [12], the water management system for acid sulphate land with overflow type B should use a oneway flow system, but the condition of the water system at the study site is still not well organized, most of the floodgates are damaged or even missing. These conditions can cause the management of the water system carried out in the research plots to be not optimal.

pH periodic of Groundwater

The results of periodic pH analysis of water on land plots are presented in Figure 2. Observation of pH values was carried out by taking water samples from 10 physiometers installed in the observation plots. The pH value at the beginning of the observation until the end of the observation did not show a significant change. The pH value in the treatment without drains (control) showed a higher value than the ditch treatment, but at the end of the harvest the pH value between treatments was relatively the same because the land conditions were flooded until it reached a positive value as shown in figure 2.



	15-Oct-18	22-Oct-18	29-Oct-18	5-Nov-18	12-Nov-18	19-Nov-18	26-Nov-18	1-Dec-18
P0	4.584	5.182	5.35	5.87	4.796	4.824	3.936	3.924
P1	4.246	4.6	4.688	4.916	4.356	4.346	3.926	3.872

Figure 2. pH periodic fluctuations of water
P0: o water inlet, P1: Channel 20cm

The pH value was highest in control and treatment with waterways were obtained on November 2018 measurement with a value of 5.87 in the control and 4.92 in the treatment with waterways.

EC water fluctuation periodic

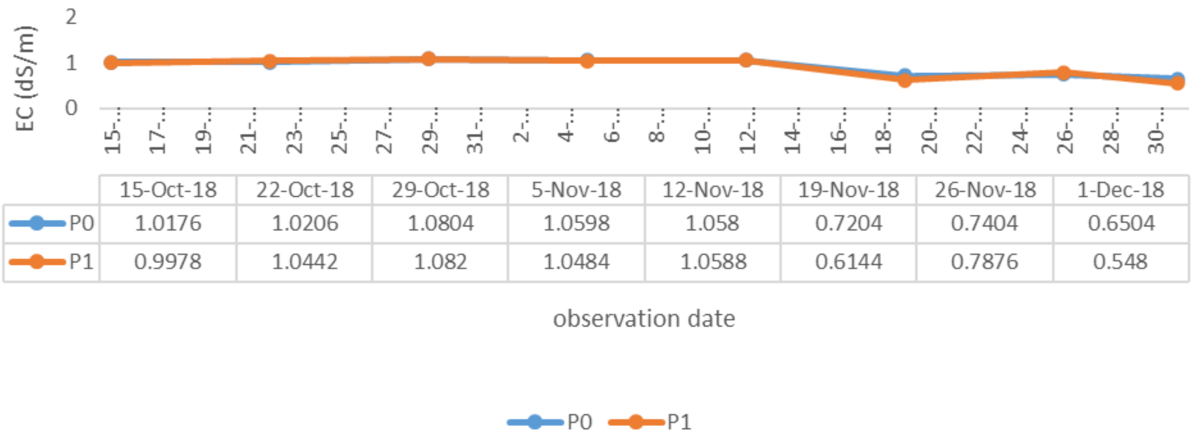


Figure 3. EC water fluctuations periodic
Information: P0: No water inlet,
P1: Channel 20 cm

The results of the analysis of the periodic electrical conductivity of water in the plots of land are presented in Figure 3. The electrical conductivity of the two treatments had relatively the same value and the relative magnitude did not change from the beginning of the measurement, namely 15 October to 12 November. Furthermore, the electrical conductivity decreased until harvest in line with the increase in water level (figure 1). The decrease in the value of the electrical conductivity is caused by the runoff from the flood which dissolves the salt, thereby reducing the electrical conductivity. According to Xinmin et al. (2022) [13], high salt content results in high EC values and adsorbed Na ratio (SAR).

Soil pH

Soil reaction or pH is an important factor in soil. The balance of processes that occur in the soil such as chemical processes and the availability of nutrients for plants is determined by pH. Apart from that, pH is also the main characteristic of swamp land.

Tabel 2. soil pH fluctuation periodic

(Treatments)		**Periodic (dap)**		
water level	**fertilization**	**30**	**60**	**90**
No settings	control	4.76a	6.02a	4.41a
	Rhizobium sp.	4.66a	5.25b	4.49a
	Mycorrhiza	4.77a	5.52ab	4.34a
	Rhizobium sp. specific for swamp land	4.84a	5.51ab	4.43a
	Rhizobium sp. + *Mycorrhiza*	4.90a	5.83ab	4.45a
Water level setting (20cm)	control	4.87a	5.74ab	4.50a
	Rhizobium sp.	4.72a	5.31b	4.53a
	Mycorrhiza	4.78a	5.83ab	4.39a
	Rhizobium sp. specific for swamp land	4.72a	5.43ab	4.39a
	Rhizobium sp. + *Mycorrhiza*	4.49a	5.55ab	4.46a
Interaction		(-)		
CV (%)		6.25	5.38	2.7

Note: the (+) sign indicates that there is an interaction between treatments, the (-) sign indicates that there is no interaction between treatments. Numbers followed by the same letter in one parameter indicate that they are not significantly different at the 5% DMRT test significance level

The results of periodic soil pH analysis are presented in table 1. Based on table 1, there was no interaction between the two treatments at the pH value. The soil pH value at 30 dap (day) after transplanting was not significantly different between treatments and had a low value, i.e. all treatments showed a pH value of less than 5. The highest pH value was in the treatment without channels with the addition of Rhizobium sp. and Mycorrhiza which is equal to 4.9 and the lowest is in the treatment with waterways with the addition of Mycorrhiza and rhizobium which is equal to 4.49. The highest pH value decreased so that it was lower than at 30 dap and 60 dap measurements. This is because at 90 dap the research area was flooded.

The water level without channels and without the addition of biological fertilizers is lower so that acid sulfate soils are in a stagnant condition. According to Stone et al (1998) [14], under flooded conditions, acid sulfate soils are in a stable condition because they are not oxidized. When the groundwater level drops, the sulfidic material can undergo oxidation which produces sulfuric acid which causes acidity in the soil.

EC soil periodic

(Treatments)		**Periodic (DAP)**		
water level (cm)	**Fertilization**	**30**	**60**	**90**
No setting	control	308,53a	279,27a	256,67a
	Rhizobium sp.	341,03a	329,80a	248,83a
	Mycorrhiza	283,07a	275,47a	301,23a
	Rhizobium sp. specific for swamp land	356,03a	332,77a	289,27a
	Rhizobium sp. + Mycorrhiza	267,83a	336,97a	258,57a
Water level setting (20cm)	Control	333,87a	288,30a	211,60a
	Rhizobium sp.	356,57a	289,07a	261,90a
	Mycorrhiza	251,17a	294,60a	299,43a
	Rhizobium sp. specific for swamp land	384,27a	290,13a	218,53a
	Rhizobium sp. + Mycorrhiza	315,80a	249,60a	279,00a
Interaction		(-)	(-)	(-)
CV (%)		20,33	25,25	24,23

Tabel 3. Periodic soil EC (dS/m)

(Treatments)		**Periodic (dap)**		
Water level	**fertilizer**	**30**	**60**	**90**
	control	0.32a	0.34ab	0.19a
No settings	*Rhizobium sp.*	0.40a	0.38ab	0.22a
	Mycorrhiza	0.26a	0.30b	0.19a
	Rhizobium sp. specific for swamp land	0.34a	0.34ab	0.22a
	Rhizobium sp. + Mycorrhiza	0.27a	0.37ab	0.20a
Water level setting (20cm)	control	0.28a	0.32ab	0.19a
	Rhizobium sp.	0.40a	0.40a	0.22a
	Mycorrhiza	0.34a	0.34ab	0.19a
	Rhizobium sp. specific for swamp land	0.30a	0.37ab	0.20a
	Rhizobium sp. + Mycorrhiza	0.39a	0.39a	0.21a
Interaction		(-)		
CV (%)		26.22	12.95	24.87

Note: the (+) sign indicates that there is interaction between treatments, the (-) sign indicates that there is no interaction between treatments. Numbers followed by the same letter in one parameter show no significant difference at the significant level of the 5% DMRT

The results of periodic soil conductivity analysis are presented in table 2. Based on table 2, there was no interaction between the two treatments on the EC value. Treatment of Rhizobium sp. with the water management system showed the highest EC value of 0.4 dS/m and the Mycorrhiza treatment without drainage management showed the lowest pH value of 0.3 dS/m. According to Balittanah (2009) [15] the value of soil EC < 1 dS/m is included in the very low level. From the measurement results above, each treatment has an electrical conductivity value of <4 dS/m, which means that the soil is still in the normal category for its salinity level according to the Gunal *et al.* (2021) [16], and does not interfere with plant growth. The rising water level due to the high tide that occurs at 60 dap measurement dissolves the salt thereby reducing the value of EC.

Table 4. Potensial Redox (soil Eh mV)

Note: the (+) sign indicates that there is interaction between treatments, the (-) sign indicates that there is no interaction between treatments. Numbers followed by the same letter in one parameter show no significant difference at the significant level of the 5% DMRT test

Redox potential or Eh is an important reaction that occurs in the soil besides pH. The Eh value indicates oxidation-reduction activity. Table 3 presents the effect of high water level treatment and biological fertilizers on Eh. Based on table 4, there was no interaction between the two treatments on the Eh value and there was no significant difference between the treatments. This shows that the application of biological fertilizers and water level adjustment have no effect on the Eh value. The measured Eh values ranged from 211.60 mV to 356.03 mV. According to Husson (2013) [17], the optimal Eh value for plant growth ranges from +400 to +450 mV. Plant growth declines rapidly at Eh below +350 mV.

Soil Total N

Nitrogen is one of the macro essential nutrients that plants really need for growth in vegetative vases. Total nitrogen is nitrogen in a form available to plants or not available to plants. Table 4 presents the effect of water level regulation and biological fertilizers on periodic total nitrogen.

Tabel 4. Soil Total N (%)

(Treatments)		Periodic (DAP)		
Water level	**fertilization**	**30**	**60**	**90**
No setting	control	0.55a	0.50ab	0.62a
	Rhizobium sp.	0.50a	0.52ab	0.63a
	Mycorrhiza	0.54a	0.57a	0.56a
	Rhizobium sp. specific for swamp land	0.54a	0.53ab	0.62a
	Rhizobium sp. + *Mycorrhiza*	0.52a	0.52ab	0.59a
Water level setting (20cm)	control	0.51a	0.49ab	0.59a
	Rhizobium sp.	0.50a	0.47b	0.55a
	Mycorrhiza	0.52a	0.51ab	0.61a
	Rhizobium sp. specific for swamp land	0.48a	0.53ab	0.56a
	Rhizobium sp. + *Mycorrhiza*	0.51a	0.51ab	0.59a
Interaction		(-)		
CV (%)		6.95	6.16	8.17

Note: the (+) sign indicates that there is interaction between treatments, the (-) sign indicates that there is no interaction between treatments. Numbers followed by the same letter in one parameter show no significant difference at the significant level of the 5% DMRT test

Based on table 4, there was no interaction between the two treatments at the N value. The N value did not show a significant difference between the treatments except for observations made at 60 dap. According to Hardjowigeno (2010) [18], the process of loss of nitrogen in the soil can be caused by absorption by plants, used by microorganisms, N is still in the form NH_4^+ which is bound by clay minerals so it cannot be used by plants, N is also in the form NO_3^- which is easily washed away by rainwater, and poor air fertility can cause denitrification and also volatilization in the form of NH_3 (ammonia). The Mycorrhiza treatment without a water management system showed the highest total N value of 0.57 and the Rhizobium sp. with the drainage management system showed the lowest total N value of 0.47.

Soil available P

Element P is a macro-essential macro nutrient that is needed by plants for growth in the generative vase, especially during the formation of pods. P or available phosphorus is phosphorus in forms that can be absorbed by plants, namely the anions $H_2PO_4^-$ and HPO_4^{2-}. Table 4.4 presents the effect of water level regulation and biological fertilizers on periodic soil available P.

Tabel 5. Soil available-P (mg/kg)

Treatments		Periodic (DAP)		
Water level	**Fertilization**	**30**	**60**	**90**
No wetting	control	47.15 a	38.90 a	34.43ab
	Rhizobium sp.	37.80 a	55.43 a	33.79ab
	Mycorrhiza	39.25 a	46.46 a	35.76a
	Rhizobium sp. specific for swamp land	54.76 a	35.52 a	36.94a
	Rhizobium sp. + *Mycorrhiza*	43.42 a	46.07 a	34.95ab
Water level setting (20cm)	control	42.78 a	27.47 a	24.36ab
	Rhizobium sp.	24.21 a	38.14 a	25.21ab
	Mycorrhiza	31.86 a	32.52 a	24.22ab
	Rhizobium sp. specific for swamp land	31.86 a	31.69 a	27.40ab

	Rhizobium sp. + *Mycorrhiza*	32.04 a	33.18 a	20.32b
Interaction		(-)		
CV (%)		32.92	34.07	19.08

Note: the (+) sign indicates that there is interaction between treatments, the (-) sign indicates that there is no interaction between treatments. Numbers followed by the same letter in one parameter show no significant difference at the significant level of the 5% DMRT test

At 90 dap measurement there was a significant difference in available P content between treatments. Treatment of Rhizobium sp. without a water management system showed the highest available P value of 36.94 ppm and Rhizobium sp. + Mycorrhiza with a drainage management system showed the lowest available P value of 20.32 ppm.

Soil K

Tabel 6. Soil K (Cmol(+)/kg)

Treatments		**Periodic (dap)**		
Water level	**Fertilization**	**30**	**60**	**90**
No setting	control	0.42a	0.45a	0.47a
	Rhizobium sp.	0.42a	0.43a	0.44a
	Mycorrhiza	0.34a	0.42ab	0.37a
	Rhizobium sp. specific for swamp land	0.40a	0.28b	0.35a
	Rhizobium sp. + *Mycorrhiza*	0.39a	0.39ab	0.40a
Water level setting (20cm)	control	0.36a	0.37ab	0.47a
	Rhizobium sp.	0.30a	0.37ab	0.38a
	Mycorrhiza	0.39a	0.32ab	0.33a
	Rhizobium sp. specific for swamp land	0.35a	0.37ab	0.33a
	Rhizobium sp. + *Mycorrhiza*	0.40a	0.38ab	0.35a
Interaction		(-)		
CV(%)		20,86	17,28	20,35

Note: the (+) sign indicates that there is interaction between treatments, the (-) sign indicates that there is no interaction between treatments. Numbers followed by the same letter in one parameter show no significant difference at the significant level of the 5% DMRT test

According to Balittanah (2009) [15] land value of 0.1-0.3 is classified as low and 0.4-0.5 is classified as moderate. From the measurement results, moderate to low K values were obtained. According to Widjaja and Adi (1997) [19], when there is an acidification process (acid pH conditions) nutrient cations in the form of Ca, Mg, and K will experience pressure and be leached by H+ ions and will be leached with water leaving the soil body. Therefore, often the availability of cations Ca, Mg, and K in peat soils is so low.

Organic -C

Table 7. Organic-C (%)

Treatments		**Periodic (DAP)**		
Water level	**Fertilization**	**30**	**60**	**90**
No setting	control	7.74a	7.19a	8.01a
	Rhizobium sp.	7.36a	7.51a	7.93a
	Mycorrhiza	7.21a	7.76a	7.48a
	Rhizobium sp. Sampy land spesific	7.42a	7.34a	7.96a
	Rhizobium sp. + *Mycorrhiza*	7.87a	7.80a	6.66a
Water level setting (20cm)	control	7.94a	7.57a	8.01a
	Rhizobium sp.	7.03a	7.00a	7.76a
	Mycorrhiza	7.38a	7.53a	7.70a
	Rhizobium sp. Swampy land spesific	6.77a	6.94a	8.29a
	Rhizobium sp. + *Mycorrhiza*	7.31a	7.47a	8.77a
Interaction		(-)		
CV(%)		6.07	7.31	12.82

Note: the (+) sign indicates that there is interaction between treatments, the (-) sign indicates that there is no interaction between treatments. Numbers followed by the same letter in one parameter show no significant difference at the significant level of the 5% DMRT test

Organic matter is the result of the decomposition of the remains of living things decomposed by microorganisms in the soil. Organic carbon is the conversion value of organic matter. Organic matter plays a role in improving the physical, biological and chemical properties of the soil as well as a source of macro and micro nutrients needed by plants.

The effect of the application of biological fertilizers and water management systems on the periodic organic carbon content is shown in table 10. Based on the analysis results in table 10 above, there was no interaction between the two treatments on the organic carbon content in the soil. The organic carbon content in the soil did not show a significant difference between the treatments. The highest organic carbon value was in the addition of Rhizobium sp. and Mycorrhiza with a water level setting of 8.77%. Table 4.1.10 shows that the C-Organic content at harvest or at 90 dap showed an increase compared to the C-Organic conditions at 30 dap.

Soybean crop yields

Table 8. Soybean crop yields (Ton/Ha)

Treatments		Dry Seed Productivity (Ton/Ha)
Water level	Fertilization	
No setting	control	1.23a
	Rhizobium sp.	1.33a
	Mycorrhiza	1.33a
	Rhizobium sp. specific for swamp land	1.44a
	Rhizobium sp. + Mycorrhiza	1.28a
Water level setting (20cm)	control	1.39a
	Rhizobium sp.	1.44a
	Mycorrhiza	1.49a
	Rhizobium sp. specific for swamp land	1.44a
	Rhizobium sp. + Mycorrhiza	1.55a
Interaction		
CV (%)		16.98

Note: the (+) sign indicates that there is interaction between treatments, the (-) sign indicates that there is no interaction between treatments. Numbers followed by the same letter in one parameter show no significant difference at the significant level of the 5% DMRT test

There was no interaction between the two treatments on soybean production. Soybean production results did not show a significant difference between the treatments. Based on table 8, the highest productivity was in the treatment by adjusting the water level and the addition of Rhizobium sp. + Mycorrhiza with a value of 1.55 tons/ha, while the lowest productivity was in the control plot or without water level regulation and without the addition of biological fertilizers with a value of 1.23 tons/ha. This happens because during the filling period of the pods, the ground water level (presented in Figure 4) rises to a positive value or is above the soil surface, which in turn can interfere with root respiration, thereby disrupting the formation of biomass which has an impact on inhibition of filling and formation of pods. The rise in the groundwater level until flooding brings drainage water that is acidic in nature to interfere with the absorption of nutrients by plants due to the low pH value in measured groundwater. The application of Rhizobium and Mycorrhiza on acid soils can increase the uptake of N and P, but there was no significant difference in the research conducted. This is because flooding occurs so that the rhizosphere is in a reductive condition which causes the activity of Rhizobium and mycorrhiza to be disrupted and even stopped due to the low oxygen content in the rhizosphere.

These results, although not significant, are quite promising, because other research shows that co-inoculation of rhizobia and mycorrhizal fungi can be utilized biotechnologically to offer a solution to food insecurity [20], Among soil-borne microbes, the arbuscular mycorrhizal fungi (AMF, Glomeromycota) are key components of natural and anthropogenic ecosystems. AMF can mediate substantial benefits in legumes such as soybean, because the plants form symbiotic associations with both P-acquiring AMF and N_2-fixing rhizobia, establishing tripartite symbioses that have synergistic effects on nutrient acquisition and growth of the host plants as well as positive effects on one another [21].

Conclusion

1. Setting the water level without channels and without the addition of biological fertilizers for soybean cultivation during the dry season in type B tidal land, is effective in maintaining soil pH that can be tolerated by soybean plants.
2. There is no interaction and no significant effect on the regulation of the water level with the ditch and the addition of biological fertilizers on the productivity of soybean plants due to an increase in the water level.

Suggestion

1. Planting time for soybean cultivation on tidal land is better done during the dry season, namely from May to September because the water demand for soybeans can still be met from rainfall during the dry season and paddy fields are not in a flooded condition.
2. Water management for soybean cultivation during the dry season period (May to September) does not need to be done by making canals in paddy fields because it is not effective for increasing soybean production.

REFERENCES

1. P.B. Simatupang, B. Sayaka, S. Saktyannu, M. Marianto, M. Ariani, dan N. Syafa'at, 2003, Analisis kebijakan ketahanan pangan dalam era globalisasi dan otonomi daerah.
2. Indonesian Agricultural Statistics Center for Agricultural Data and Information System, Ministry ofAgriculture Republic of Indonesia 2019.pp. 105-12 *(16) (PDF) Soybean in Indonesia: Current Status, Challenges and Opportunities to Achieve Self-Sufficiency*. Available from: https://www.researchgate.net/publication/357020534_Soybean_in_Indonesia_Current_Status_Challenges_and_Opportunities_to_Achieve_Self-Sufficiency [accessed Sep 25 2023].
3. LV. Kochian, Hoekenga OA, Pineros MA, How do crop plants tolerate acid soils? -

Mechanisms of aluminium tolerance and phosphorous efficiency, Annu Rev Plant Biol. 55:459-493 (2004).
4. T. Notohadiprawiro, Tanah dan Lingkungan [Land and Environment]. Second Press. Pusat Studi Sumberdaya Lahan (PPSL) Univ. Gadjah Mada. Yogyakarta. 187 hal (2000).
5. S. Muhrizal, S., J. Shamsuddin., Fauziah., M.A.H. Husni, 2006, Changes in iron-poor acid sulphate soil upon submergence, Geoderma. 131: 110-122 (2006).
6. R. Seenivasagan, and O.O Babalola, Utilization of Microbial Consortia as Biofertilizers and Biopesticides for the Production of Feasible Agricultural Product, *Biology* **2021**, *10*, 1111. https://doi.org/10.3390/biology1011111. (2021).
7. J. Shamshuddin, A. Elisa Azura, M.A.R.S. Shazana, C.I. Fauziah, Q.A. Panhwar, U.A. Naher, *Properties and Management of Acid Sulfate Soils in Southeast Asia for Sustainable Cultivation of Rice, Oil Palm, and Cocoa.* In Donald L. Sparks, editor: *Advances in Agronomy*, Vol. 124, Burlington: Academic Press, 2014, pp. 91-142. ISBN: 978-0-12-800138-7 © Copyright 2014 Elsevier Inc. Academic Press
8. H. Subagyo, H, Klasifikasi dan penyebaran lahan rawa, hlm.1- 22, Dalam D.A. Suriadikarta, U. Kurnia, Mamat H.S., W. Hartatik, dan D. Setyorini (Ed.). *Karakteristik dan Pengelolaan Lahan Rawa. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian*, Bogor (2006).
9. K. Subagyono, S I Wayan, EE Ananto. Penataan lahan dan tata air mikro pengembangan SUP lahan pasang surut Sumatera Selatan, P2SLPS2. Badan Litbang Pertanian, (1999).
10. D. Dent, Acid sulphate soils: a base line for research and development. ILRI Publication 39, International Institute for Land Reclamation and Improvement. Wageningen, TheNetherlands, (1986)
11. Haryono, M. Noor, H. Syahbuddin, and M. Sarwani. Lahan Rawa: Penelitian dan Pengembangan. Badan Penelitian dan Pengembangan Pertanian Kementrian Pertnian, Bogor, (2013).
12. DA., Suriadikarta, Pengelolaan lahan sulfat masam untuk usaha pertanian. Jurnal Litbang Pertanian, Bogor, (2005)
13. L. Xinmin, Y. Zhu, J.M Bennett, L. Wu, H. Li, Effects of sodium adsorption ratio and electrolyte concentration on soil saturated hydraulic conductivity, Geoderma, Volume 414 (2022), 115772, ISSN 0016-7061, https://doi.org/10.1016/j.geoderma.2022.115772.
14. Y. Stone, CR Ahern, and Blunden B. Acid Sulfate Soils Manual, Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia (1998)
15. Balai Penelitian Tanah (Soil Research Institute). Analisis Kimia Tanah, Tanaman, Air, dan Pupuk. Badan Penelitian dan Pengembangan Pertanian Departemen Pertanian.pp 143. (2009).
16. E. Gunal, X Wang, OM Kilic, M Budak, S Al Obaid,MJ Ansari, M Brestic. 2021. Potential of Landsat 8 OLI for mapping and monitoring of soil salinity in an arid region: A case study in Dushak, Turkmenistan. Plos One 16 (11): E0259695. https://doi.org/10.1371/journal.pone.0259695 , (2021)
17. O. Husson. 2013. Redox potential (Eh) and pH as drivers of soil/plant/microorganism systems : a transdisciplinary overview pointing to integrative opportunities for agronomy. Plant Soil. 362:389-417 (2017).
19. I.P.G. Wijaya Adhi, Pengelolaan lahan rawa pasang surut dan lebak. Jurnal Penelitian dan Pengembangan Pertanian V(1): 1-9 (1986).
20. Igiehon, O.N., Babalola, O.O. *Rhizobium* and Mycorrhizal Fungal Species Improved Soybean Yield Under Drought Stress Conditions. *Curr Microbiol* 78, 1615–1627 (2021). https://doi.org/10.1007/s00284-021-02432-w
21. V.S. Faggioli, F. Covacevich, G. Grilli, *et al.* Environmental response of arbuscular mycorrhizal fungi under soybean cultivation at a regional scale. *Mycorrhiza* **32**, 425–438 (2022). https://doi.org/10.1007/s00572-022-01093-2