Agronomical Performances of Soybean Cultivated under Saturated Soil Culture on Tidal Swamps

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Abstract

Saturated soil culture (SSC) is a cultivation technology mantaining water depth constanly to make soil layer in the saturated condition. This paper resumes of two experiments to evaluate the effect of water depth and bed width, and leaching time and varieties of soybean cultivated under SSC on tidal swamp. The research was conducted at Banyu Urip, Banyuasin, South Sumatra from April to August 2010. In the first experiment, water depth in the furrow irrigation as main-plot consisted of 10 and 20 cm under soil surface (USS) and bed widths as sub-plot consisted of 2, 4, 6 and 8 m. The results showed that the highest grain yield was obtained on 20 cm USS water depth and bed width 2 m (4.15 ton/ha), it was significantly different from those at bed width 4 m (2.59 ton/ha), 6 m (1.84 ton/ha) and 8 m (1.74 ton/ha). The grain yield on water depth 10 cm USS and bed width 2 m obtained was 3.43 ton/ha, it was significantly different from those at bed width 4 m (2.46 ton/ha), 6 m (1.75 ton/ha) and 8 m (1.68 ton/ha). In the second experiment, leaching time as main-plot consisted of without leaching, every 2, 4 and 6 weeks, and soybean variety as sub-plot consisted of Tanggamus, Slamet, Willis and Anjasmoro. The results showed that interaction between leaching time and varieties did not significally affect grain yield, varieties responded leaching time differently. The highest grain yield was obtained by Anjasmoro variety with leaching time every 2 weeks (4.06 ton/ha) but it was not significantly different from those with leaching time every 4 weeks (3.99 ton/ha) and every 6 weeks (3.93 ton/ha). From these experiments, water depth 20 cm USS and bed width 2 m may be recommended for SSC soybean cultivation on tidal swamp, and presumably, leacing time every six weeks will gain more effective economically and technically.

Keywords: leaching time, saturated soil, tidal swamp, water depth, bed width

Introduction

One alternative system to develop soybean cultivation in Indonesia is to optimize the use of marginal land, and tidal swamp is one of the potential ecosystem for future soybean production. Indonesia has about 20 million ha tidal swamps, 9 millions ha out of them is appropriate for agriculture, 2 milions is suitable for soybean (Noor and Sabur, 2007). The major constrain of producing soybean in tidal swamp due to its high pyrite content. When pyrite is oxidized, soil pH decreases. Djayusman *et al.* (2001) reported that high pyrite content suppressed the productivity of soybean on tidal swamps to only about 800 kg/ha. SSC is a technology in cultivation giving water permanently, maintains and keeps its depth constantly (about 5 cm USS). This makes soil layer in saturated condition. In SSC, watering is started from the beginning of growth to maturity stage. By keeping the water-table constantly, soybean will be avoided from negative effect of inundation on soybean growth, because soybean will acclimatize and improve its growth (Troedson *et al*., 1985).

Soil water management can be applied to reduce pyrite content where the soil is in reductive condition and able to support soybean growth. SSC technology is one of soil water managements studied in highland and succeed to increase soybean production (Indradewa *et al.*, 2004; Ghulamahdi *et al.*, 2006). This offers the chance to reduce the pyrite, hence increase soybean production on tidal swamps. Adisarwanto (2001) suggested for soybean cultivation using bed width less than 2 m. The addition of bed width will reduce the use of labor in the preparing land to make the trench, but to consider the ability of water seeped from the trench into the middle of beds. Indradewa *et al*. (2002) reported that the inundation in the trench with 3-4 m wide bed was the ideal plot. There was no difference in the influence of bed width on the growth and yield of soybean. Response of soybean to saturated condition varied between varieties and the later-maturing soybean was better than the earlier one (CSIRO, 1983; Ghulamahdi *et al*., 1991; Ghulamahdi, 2008; Ghulamahdi and Nirmala, 2008). Many varieties of soybean have been studied in their response on acid soil. Alihamsyah and Ar-Riza (2006) found that Tanggamus, Wilis and Slamet were varieties that could adapt well on inland. Leaching of land can decrease negative effect of poisonous material (Fe, Al, Mn) to the soybean growth. The frequency of water drainage from the trench will effect to the content of poisonous material. The objectives of the research were : 1) to study the effect of water depth and bed width , and 2) to investigate the effect of leaching time and varieties to the growth and production of soybean under SSC on tidal swamps.

Materials and Methods

This research was conducted on tidal swamps land in Banyuurip Village of Tanjung Lago Sub District, Banyuasin District, South Sumatera, Indonesia from April to August 2010. In the first experiment, water depth in the furrow irrigation as main-plot consisted of 10 and 20 cm under soil surface (USS) and bed widths as sub-plot consisted of 2, 4, 6 and 8 m. This experiment used Tanggamus variety. In the second experiment, leaching time as main-plot consisted without leaching, every 2, 4 and 6 weeks, and soybean variety as sub-plot consisted of Tanggamus, Slamet, Willis and Anjasmoro. Each main plot was surrounded by furrow irrigation. Water was given at planting time and kept until the maturity stage and made plots in wet condition. Two weeks before planting, plots were applied with 2 ton dolomite/ha, 400 kg SP18/ha, and 100 kg KCl/ha. Soybeans were sprayed with 10 g Urea/l water at 2, 4, 6 weeks after planting to support acclimatization.

At planting date, seeds were inoculated with *Rhizobium sp* and treated with insecticide with active agent Carbosulphan 25.53%. Seeds were planted in 2 x 5 m plot size, 20 x 25 cm planting distance, 2 seeds per hole. The observed variables were : nodule, root, stalk, and leaves dry weight at 6 weeks after planting (WAP); plant height, number of branch, fill pod, and empty pod per plant, seed productivity (ton/ha), and 100-seed dry weight at harvest time.

Results and Discussion

In the first experiment, there was the influence of water depth on the leaf, stalk, root and nodule dry weight at 6 WAP. The leaf, stalk, root and nodule dry weight were significantly higher in the water depth 20 cm USS than that ini 10 cm USS (Table 1). This was predicted because the root growing zone in the water depth 20 cm USS wider than 10 cm USS, so it provied adequate for maximum root growth. According to Suwarto *et al.* (1994) water depth significantly influenced on the leaf, stalk, root and nodule dry weight.

Water depth affected the plant height, number of branch and fill pod per plant, but there was no influence of water depth on the number of empty pod and 100 seed weight. Plant height, number of branch and fill pod and productivity of soybean were significantly higher in the water depth 20 cm USS than those in 10 cm USS (Table 2).

Table 1. The effect of water depth on leaf, stalk, root, and nodule dry weight at 6 WAP

Water Depth (cm)	Leave (g)	Stalk (g)	Root (g)	Nodule (g)
10	3.52b	3.64b	0.73b	0.33b
20	4.51a	4,84a	0.99a	0.48a

Note: numbers followed by the same letter on the same column are not significantly different with Duncan multiple range test at 5%.

Table 2. The effect of water depth on plant height, number of branch and fill pod, and productivity at harvest time

Water Depth (cm)	Plant Height (cm)	Branch/Plant	Fill Pod/Plant	Productivity (ton/ha)
10	70.66b	4.22b	67.83b	2.33b
20	73.86a	4.55a	71.83a	2.58a

Note: numbers followed by the same letter on the same column are not significantly different with Duncan multiple range test at 5%.

There was the influence of bed width on the leaf, stalk, root and nodule dry weight. The leaf, stalk, root and nodule dry weight were significantly higher in the bed width 2 m than that with the other bed widths (Table 3). This was predicted because the water seepage from the ditch into the middle of bed highest distributed on the bed width 2 m.

Table 3. The effect of bed width on leaf, stalk, root, and nodule dry weight at 6 WAP

Variables	Bed Width 2 m	Bed Width 4 m	Bed Width 6m	Bed Width 8m
Leave dry weight (g)	4.57a	4.29ab	4.03ab	3.17b
Stalk dry weight (g)	5.27a	4.48ab	4.09ab	3.11b
Root dry weight (g)	1.09a	0.83ab	0.78ab	0.72b
Nodule dry weight (g)	0.58a	0.40b	0.34cb	0.29c

Note: numbers followed by the same letter on the same line are not significantly different with Duncan multiple range test at 5%.

At harvest time, there was the influence of bed width on the number of branch, fill pod per plant, seed productivity, and 100 seed weight, but there was no influence on the plant height and empty pod. Number of branch, fill pod, seed productivity, and 100 seed weight were significantly higher in bed width 2 m than those in the other bed widths (Table 4). Indradewa *et al.* (2002) concluded that there was no difference in the effect of bed width on soybean growth and yield.

Table 4. The effect of bed width on number of branch and fill pod, productivity and 100 seed weight at harvest time

Variables	Bed Width 2 m	Bed Width 4 m	Bed Width 6 m	Bed Width 8 m
Branch/plant	4.71a	4.41ab	4.33ab	4.05b
Fill Pod/plant	80.17a	73.50b	65.17c	60.17d
Productivity (tones / ha)	3.79a	2.52b	1.79c	1.71d
100 seeds weight (g)	11.89a	11.30ab	10.98b	10.96b

Note: numbers followed by the same letter on the same line are not significantly different with Duncan multiple range test at 5%.

There was the influence of water depth and bed width interaction on the leaf, stalk, root and nodule dry weight. The leaf, stalk, root and nodule dry weight were significantly higher in the water depth 20 cm USS with bed width 2 m than those in the other treatments (Table 5).

At harvest time there was the influence of water depth and bed width interaction on the the plant height, number of branch, fill pod, seed productivity and 100 seed weight of soybean. There was no interaction effect of water depth and bed width interaction on the number of empty pods. Plant height, number of branch and fill pod, seed productivity and 100 seed weight were significantly higher in the water depth 20 cm USS with bed width 2 m than those in the other treatments (Table 6).

Table 5. The effect of interaction of water depth and bed width on leaf, stalk, root, and nodule dry weight at 6 WAP

Variables	Water Depth (cm) x Bed Width (m)							
	10x2	10x4	10x6	10x8	20x2	20x4	20x6	20x8
Leaf dry weight (g)	3,22bc	3,68bc	4,14bc	3,90b	5,92a	4,91ab	3,92bc	3,29bc
Stalk dry weight (g)	3,58bc	3,79bc	4,16bc	3,06c	6.96a	5,17ab	4,02bc	3,19bc
Root dry weight (g)	0,69b	0,71b	0,84b	0,65b	1,50a	0,94b	0,72b	0,82b
Nodule dry weight (g)	0,34bc	0,44b	0,30cd	0,22d	0,82a	0,37bc	0,37bc	0,36bc

Note: numbers followed by the same letter on the same line are not significantly different with Duncan multiple range test at 5%.

Table 6. The effect of interaction of water depth and bed width on plant height, number of branch and fill pod, productivity, 100 seed weight at harvest time

Variables	Water Depth (cm) x Bed Width (m)							
	10x2	10x4	10x6	10x8	20x2	20x4	20x6	20x8
Plant Height	73,55ab	72,83ab	68,06b	67,65b	77,70a	77,23a	71,14a	70,23b
Branch/plant	4.30ab	4.31ab	4.25ab	3.90b	4.68a	4.48ab	4.41ab	4.18ab
Productivity (tonnes/ha)	3.43b	2.46d	1.75f	1.68g	4.15a	2.59c	1.84e	1.74f

Note: numbers followed by the same letter on the same line are not significantly different with Duncan multiple range test at 5%.

In the second experiment, the leaching time did not affect the variables growth, yield component, and yield of soybean dry, but that only affected the nodule dry weight. The leaching time every 2 weeks gave the nodule dry weight per plant significantly different with that at every 4 and 6 weeks, but did not different with without leaching (Table 7).

Table 7. The Effect of leaching time on leaf, stalk, root, and nodule dry weight at 6 WAP

	Without	Every 2 Weeks	Every 4 weeks	Every 6 weeks
Nodule dry weight (g)	0.18ab	0.19a	0.11b	0.13b

Note: numbers followed by the same letter on the same line are not significantly different with Duncan multiple range test at 5%.

The variety affected the root, stalk dry weight, and seed productivity, but did not affect the other variables (Table 8). Stalk and root dry weight of Slamet were highest than those of the other varieties. The highest of seed productivity was obtained on Anjasmoro (Table 8).

Table 8. The Effect of variety on leaf, stalk, root, and nodule dry weight at 6 WAP

Variables	Tanggamus	Slamet	Wilis	Anjasmoro
Stalk dry weight (g)	4.86ab	5.60a	4.07b	3.85b
Root dry weight (g)	0.77ab	0.87a	0.69ab	0.63b
Productivity (ton/ha)	2.73b	2.39b	2.48b	3.83a

Note: numbers followed by the same letter on the same line are not significantly different with Duncan multiple range test at 5%.

The leaching time and variety interaction did not affect the seed productivity (Table 9). The highest grain yield was obtained by Anjasmoro variety with leaching time every two weeks (4.06 ton/ha), but it was not significally different from those with leaching time every four weeks (3.99 ton/ha) and every six weeks (3.93 ton/ha). This suggested that the leaching time every 6 weeks gained more effective economically and technically. This productivity of Tanggamus in 2010 was lower than 2009 (Ghulamahdi, 2009). It was predicted that the Tanggamus was more responsive to the higher solar radiation than lower solar radiation. The dry climate was in 2009, and wet climate was in 2010. Based on visualization observation in the field the size of leaf of Tanggamus in dry climate was wider than that in wet climate. Irwan (2006) stated that at high temperatures and low humidity, solar radiation stimulated the emergence of flower buds into flowers.

Table 9. The effect of interaction on leaching time and variety on the seed productivity (ton/ha)

Leaching Time	Tanggamus	Slamet	Willis	Anjasmoro
Without	2.31	2.16	2.44	3.36
Every 2 weeks	3.08	2.41	2.46	4.06
Every 4 weeks	2.80	2.62	2.71	3.99
Every 6 weeks	2.73	2.40	2.29	3.93

Note: numbers followed without letter are not significantly different with Duncan multiple range test at 5%.

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