International Journal of Agricultural Technology 2025 Vol. 21(1):217-230
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Weed control in water-saturated soybean cultivation in the coastal area

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Setyowati, N., Pujiwati, H., Rasid, R. N., Muktamar, Z. and Fahrurrozi, F. (2025). Weed control in water-saturated soybean cultivation in the coastal area. International Journal of Agricultural Technology 21(1):217-230.

Abstract The study indicated that soybean growth and yield under water-saturated conditions did not significantly differ among various weed control periods or weeding frequencies. Soybeans weeded twice or three times grew similarly to those weeded once. During the study, soybean growth was inhibited even after weed control, indicating faster weed growth compared to soybeans. At 2, 3, and 4 weeks after planting, the predominant weed species was Fimbristylis miliacea, followed by Ludwigia octovalvis and Cyperus sphacelatus R. By harvest time, the experimental site was dominated by *Cyperus halpan*, *F. miliacea*, *Fimbristylis ciliaris*, and *C. sphacelatus* with SDR (Summed Dominance Ratio) values of 25.45%, 24.86%, 13.88%, and 11.67%, respectively. These findings are crucial for managing weeds in soybean cultivation under water-saturated emvironment.

Keywords: Coastal area, Low land, Soybean, Water-saturated cultivation, Weed control

Introduction

Soybeans play a crucial role in Indonesia's economy and culture. This crop is a primary protein source for Indonesians and is essential in traditional dishes like tempeh, tofu, and soy sauce, which are staples in the Indonesian diet. Soybeans are consumed directly and used in various industrial processes such as cooking oil production, snack foods, and animal feed (Yulifianti *et al*., 2018). This crop is particularly important in regions like East Java, Central Java, and Lampung. The Indonesian government often supports soybean farmers with subsidies, infrastructure development, and research initiatives to enhance soybean productivity and quality. There are various soybean cultivation methods, including the water-saturated cultivation technique (Susilo *et al*., 2019a; Susilo *et al*., 2019b; Perkasa *et al*., 2016).

Water-saturated cultivation is a technique designed for areas with high water capacity. This method involves maintaining water in channels (trenches)

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and elevating the soil surface so that only the plant roots are in a water-saturated condition (Ghulamahdi, 1999). This technology can help convert swamp land into productive agricultural land. The optimal water level for water-saturated cultivation is 20 cm below the soil surface, and it is kept constant to help plants adapt and thrive (Ghulamahdi, 2017). Maintaining stable water levels in water-saturated cultivation ensures soil moisture remains at field capacity. At field capacity, soil pores are filled with water, which reduces the harmful effects of pyrite (FeS_2) on plants (Sagala *et al*., 2011). Besides water availability, weeds also pose a challenge to soybean production (Weber *et al*., 2016).

Weeds can compete for nutrients, water, light, and space, thereby hindering plant growth. Crop-weed competition intensifies when water, nutrients, and light are simultaneously limited and in demand (Efendy *et al*., 2020). Therefore, it is essential to control weeds at the appropriate time, known as the critical period, when their presence significantly impedes plant growth. Weed disturbances during this period will decrease crop yield more than during the non-critical period (Harsono, 2017). For soybean plants, the critical period for weed competition occurs two to six weeks after planting (WAP), or roughly a quarter to one-third of the plant's life. Weed invasion during early plant growth reduces soybean yields, and invasion just before harvesting affects soybean quality. Weeds can reduce soybean yields by 18% to 76% (Hendrival *et al*., 2014; Manurung and Syam'un, 2003). This research aimed to determine the optimal weeding period in water-saturated soybean cultivation.

Materials and methods

Experimental sites and design

The experiment was carried out at the Agronomy Laboratory, the Faculty of Agriculture, Bengkulu University, Indonesia, on swamp land situated 15 meters above sea level. The experiment used a Randomized Complete Block Design (RCBD) with 7 treatments, with three repetitions for each treatment. The treatments were as follows: P1 = weeding 2 weeks after planting (WAP), P2 = weeding 3 WAP, P3 = weeding 4 WAP, P4 = weeding 2 WAP and 3 WAP, P5 = weeding 2 WAP and 4 WAP, P6 = weeding 3 WAP and 4 WAP, and P7 = weeding 2 WAP, 3 WAP, and 4 WAP.

Experimental procedure

Prior to tillage, the weeds at the experimental site were controlled using a contact herbicide with the active ingredient paraquat. After two weeks, the soil was ploughed, and experimental plots measuring 1.6 m x 2.0 m (length x width) were set up with a distance of 50 cm between plots and 80 cm between blocks. Before planting, the soil was fertilized with 5 ton/ha of manure and 3.6 ton/ha of dolomite. The soybean seeds were treated with Rhizobium sp. and sown in holes 2-3 cm deep, with a planting distance of 30 cm x 25 cm. Five Furadan pellets were placed in each planting hole to prevent insect infestation, and the holes were then covered with soil.

At planting, N (urea), P (SP-36), and K (KCl) were applied at rates of 200 kg/ha, 150 kg/ha, and 100 kg/ha, respectively. The water level in the channel was maintained at 20 cm below the soil surface, with additional watering as necessary. Replanting was carried out one week after the initial planting. Insect and disease prevention was managed using insecticides containing 500 g/l of Profenofos and 25 g/l of Deltamethrin. Weeds were controlled manually at 2, 3, and 4 weeks after planting, with control frequencies of 1, 2, and 3 times, respectively, depending on the treatment. Soybeans were harvested 100 days after planting when 80% of the pods conforming the harvest criteria (dry and yellow leaves, firm pods, and brown main stems).

Data collection

Observed variables for soybeans included plant height (cm), number of leaves, number of branches, shoot fresh weight (g/plant), shoot dry weight (g/plant), root fresh weight (g/plant), root dry weight (g/plant), number of pods (pods/plant), number of filled pods (pods/plant), empty pods (pods/plant), seeds weight (g/plant), seeds weight (ton/ha). Initial soil sample was collected at the depth of 0-20 cm and analyzed for Soil pH, organic C, total-N, available-P, exchangeable-K, and exchangeable-Al.

Weed vegetation analysis

Weed vegetation was monitored by analyzing the various types of weeds present in each plot of the experimental field. Weed species were observed at 2, 3, and 4 weeks after planting (WAP) and at harvesting. According to the methodology described by Mangoensoekarjo and Soejono (2015), observations were made using the following formula:

a. Absolute frequency (AF) is the number of weed species in all sample plots.
b. The relative frequency (RF) = $\frac{\text{AF weed X}}{\text{AF all weed types}} \times 100\%$.
c. Absolute dominance (AD) is the weight of weeds from all sample plots.

d. Relative dominance (RD) = $\frac{\text{AD weed X}}{\text{AD all weed types}} \times 100\%$.
e. Absolute density (AN) is the number of weed types from all sample plots.
f. The relative density (RN) = $\frac{\text{AN weed X}}{\text{AN all weed types}} \times 100\%$.
g. Summed dominance ratio (SDR) = $\frac{RF+RD+RN}{3}$.

Data analysis

Data were analyzed using Analysis of Variance (ANOVA) at 5%. Treatment means were separated using the Least Significant Difference (LSD) test at 5%.

Results

General outlook of experimental site

The study was conducted from December 2020 to March 2021, during which total rainfall amounted to 608 mm, 374 mm, 388 mm, and 608 mm respectively. The average air temperatures were 26.3°C, 26.8°C, 27.1°C, and 27°C, and the average air humidity levels were 85%, 82%, 82%, and 85% respectively. This rainfall exceeds the average required for soybean growth. The optimal temperature for soybeans is between 25-27°C, with an average air humidity of 50% (Adie and Krisnawati, 2007; Hanafiah *et al*., 2015). The soil at the study site had a pH of 4.25 (acidic), an organic carbon content of 3.69% (high), nitrogen at 0.23% (low), available phosphorus at 3.19 ppm (low), available potassium at 0.25 me/100 g (low), and exchangeable aluminum at 1.75 me/100 g (high).

Weed vegetation assessment at the experimental site revealed that *F. miliacea, C. sphacelatus* R.*, Ludwigia octovalvis*, and *Paspalum commersonii* Lamk grew at 2, 3, and 4 WAP. There were 11 weed species at harvesting, including *F. miliacea, C. sphacelatus., L. octovalvis, C. halpan L., Fuirena ciliaris, Eragrostis curtipedicellata, P. commersonii Lamk., Galium divaricatum, Sporobolus compositus, Panicum repens,* and *Cyperus articulates.*

Analysis of variance

The analysis of variance indicated that variations in the weeding period only influenced the number of leaves at 5 and 6 weeks after planting (WAP) and the number of branches at 5 WAP. However, by week 8, there were no significant differences in the number of soybean leaves and branches across treatments, nor in other plant growth components (Table 1).

Table 1. Variance analysis of soybean growth and yield variables

Variable	F-calculated (5%)[1]	Coef. Variation (CV) (%)
Plant height 8 WAP	1.12 ns	11.20
Number of leaves 8 WAP	1.33 ns	18.73
Number of branches 8 WAP	1.27 ns	14.07
Root fresh weight	0.57 ns	27.96
Root dry weight	2.38 ns	27.23
Shoot fresh weight	1.55 ns	22.92
Shoot dry weight	0.81 ns	22.94
Number of pods/plant	1.52 ns	23.18
Number of filled pods/plant	1.69 ns	20.96
Empty pods /plant	0.57 ns	24.76
Seed weight/plant	1.01 ns	23.34
Seeds weight/Ha.	0.82 ns	24.19
F-table	3.00	

[1]number with the same letter are not significantly different at p-value > 0.05

Weed vegetation analysis

Weed vegetation analysis at 2, 3, and 4 weeks after planting (WAP) identified four weed species at the experimental site: *F. miliacea*, *C. sphacelatus* R, *L. octovalvis*, and *P. commersonii* Lamk. Among these, *P. commersonii* Lamk had the lowest Species Dominance Ratio (SDR), while *F. miliacea* had the highest (Tables 2, 3, and 4).

Table 2. Analysis of weed vegetation 2 weeks after panting

Weed species	AF	RF (%)	AD	RD (%)	AN	RN (%)	SDR (%)
Fimbristylis miliacea	12	30	42.99	45.51	478	61.13	45.55
Cyperus sphacelatus R.	11	27.5	5.91	6.26	153	19.57	17.77
Ludwigia octovalvis	12	30	41.61	44.05	129	16.50	30.18
Paspalum commersonii Lamk.	5	12.5	3.95	4.18	22	2.81	6.50

Table 3. Analysis of weed vegetation 3 weeks after panting

Weed species	AF	RF (%)	AD	RD (%)	AN	RN (%)	SDR (%)
Fimbristylis miliacea	12	31.58	49.43	40.11	349	73.32	48.34
Cyperus sphacelatus R.	11	28.95	2.62	2.13	67	14.08	15.05
Ludwigia octovalvis	8	21.05	50.45	40.94	38	7.98	23.32
Paspalum commersonii Lamk.	7	18.42	20.74	16.83	22	4.62	13.29

Table 4. Analysis of weed vegetation 4 weeks after panting

Weed species	AF	RF (%)	AD	RD (%)	AN	RN (%)	SDR (%)
Fimbristylis miliacea	12	46.15	43.61	47.94	296	74.56	56.22
Cyperus sphacelatus R.	11	42.31	2.13	2.34	80	20.15	21.60
Ludwigia octovalvis	2	7.69	41.1	45.18	17	4.28	19.05
Paspalum commersonii Lamk.	1	3.85	4.12	4.53	4	1.01	3.13

Note: Absolute frequency (AF), Relative frequency (RF), Absolute dominance (AD), Relative dominance (RD), Absolute density (AN), Relative density (RN), Summed dominance ratio (SDR)

F. miliacea is the predominant weed observed at the experimental sites 2, 3, and 4 weeks after planting (WAP), with Species Dominance Ratio (SDR) values of 45.55%, 48.34%, and 56.22%, respectively (Tables 2, 3, and 4). Similarly, *L. octovalvis* emerges as the second most dominant weed species at 2 and 3 weeks after planting, with SDR values of 30.18% and 23.32%, respectively, while *C. sphacelatus* R ranks third during these periods. The SDR of *F. miliacea* is significantly higher compared to *P. commersonii* Lamk., by a factor of 6 at 2 weeks after planting, 2.6 at 3 WAP, and 17 at 4 WAP.

The weed survey conducted at harvest revealed an increase in the number of weed species from four to eleven. At harvest, these weeds consisted of 2 broadleaves, 5 grasses, and 4 sedges (Table 5). Overall, the sedge weed group predominated among the species, accounting for more than 50% of the Species Dominance Ratio (SDR), primarily represented by *C. halpan* L. and *F. miliacea*. *L. octovalvis* dominated the broad-leaved group, *F. ciliaris* led the grasses, and *C. halpan* L. topped the sedges with SDR values of 7.89%, 13.88%, and 25.45%, respectively.

Weeds dry weight

Weed dry weight was assessed at two, three, and four weeks after planting, as well as at harvest. The dry weight of weeds increased with the duration of the weeding intervals following planting (Table 6). In the P3 treatment, weed weight was higher compared to P1 and P2 (single weeding). Conversely, weed weight decreased in treatments P4 to P7 (two or three weedings).

Table 5. Analysis of weed vegetation at harvest

Weed species	AF	RF (%)	AD	RD (%)	AN	RN (%)	SDR (%)
Broadleaves							
Ludwigia octovalvis	13	12.62	242.88	8.80	52	2.24	7.89
Galium divaricatum	1	0.97	13.37	0.48	20	0.86	0.77
Grasses							
Fuirena ciliaris	16	15.53	361.94	13.11	302	13.01	13.88
Paspalum commersonii Lamk.	8	7.77	281.67	10.20	57	2.45	6.81
Panicum repens L.	5	4.85	176.10	6.38	21	0.90	4.05
Eragrostis curtipedicellata	3	2.91	35.64	1.29	46	1.98	2.06
Sporobolus compositus	3	2.91	54.27	1.97	14	0.60	1.83
Sedge							
Cyperus halpan L.	21	20.39	523.67	18.97	859	36.99	25.45
Fimbristylis miliacea	20	19.42	718.13	26.01	677	29.16	24.86
Cyperus sphacelatus R.	12	11.65	334.81	12.13	261	11.24	11.67
Cyperus articulatus L.	1	0.97	18.32	0.66	13	0.56	0.73
Total	103	100	2760.8	100	2322	100	100

Note: Absolute frequency (AF), Relative frequency (RF), Absolute dominance (AD), Relative dominance (RD), Absolute density (AN), Relative density (RN), Summed dominance ratio (SDR)

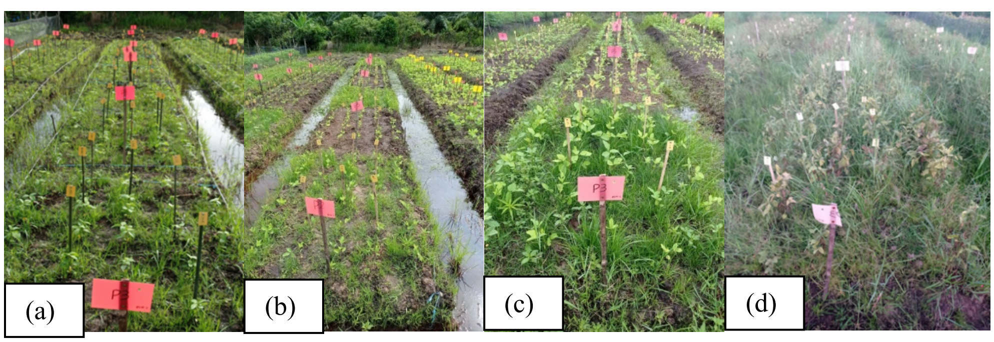

Figure 1. Effect of mechanical weed control on the growth of water-saturated cultivated soybeans at 2,3 and 4 week after planting (a, b, c) and at harvest (d)

Table 6. Weeds dry weight at 2, 3, and 4 weeks after planting (WAP)

Treatment	2 WAP	3WAP	4 WAP	Total
P_1	36.08	-	-	36.08
P_2	-	90.44	-	90.44
P_3	-	-	112.04	112.04
P_4	28.84	3.24	-	32.08
P_5	43.28	-	5.32	48.6
P_6	-	67.44	1.96	69.4
P_7	25.76	3.2	1.96	30.92

Note: P1 = weeding 2 WAP, P2 = weeding 3 WAP, P3 = weeding 4 WAP, P4 = weeding 2 and 3 WAP, P5 = weeding 2 and 4 WAP, P6 = weeding 3 and 4 WAP, P7 = weeding 2, 3 and 4 WAP, WAP: week after planting.

The dry weight of weeds at harvest was significantly higher compared to measurements taken at 2, 3, and 4 weeks after planting (WAP) (Table 7). When weeds were controlled at 2, 3, and 4 WAP, their biomass dry weight increased by 20.1 times at harvest compared to the weight observed at 2 WAP, indicating rapid weed growth during the soybean growing season. This increase was substantially greater than when weeds were only controlled at 2 WAP.

Table 7. Weeds dry weight at harvest

Treatment	Weed dry weight (g/m^2)
P_1	622.32
P_2	588.48
P_3	408.28
P_4	496.16
P_5	484.04
P_6	538.2
P_7	543.64

Note: P1 = weeding 2 WAP, P2 = weeding 3 WAP, P3 = weeding 4 WAP, P4 = weeding 2 and 3 WAP, P5 = weeding 2 and 4 WAP, P6 = weeding 3 and 4 WAP, P7 = weeding 2, 3 and 4 WAP.

Effect of weeding time on soybean plant growth and yield

It indicated that the timing of weeding did not have a significant effect on root fresh weight, root dry weight, shoot fresh weight, or shoot dry weight (Table 8). Weeding at 2 and 3 weeks after planting (WAP) (P4) resulted in higher shoot and root weights. In water-saturated cultivation, weeds thrive, which contributed to lower weights of soybean shoots and roots.

Table 8. Effect of weeding on root and shoot fresh and dry weight

Treatments	Variables			
	RFW (g)	RDW (g)	SFW (g)	SDW (g)
P_1	3.80	1.81	28.66	11.42
P_2	4.02	1.83	26.61	10.28
P_3	3.86	1.84	29.38	12.40
P_4	5.16	2.57	37.92	15.26
P_5	3.76	2.05	32.15	13.02
P_6	3.94	2.13	30.94	12.59
P_7	4.22	2.24	28.86	12.25

Note: P1 = weeding 2 WAP, P2 = weeding 3 WAP, P3 = weeding 4 WAP, P4 = weeding 2 and 3 WAP, P5 = weeding 2 and 4 WAP, P6 = weeding 3 and 4 WAP, P7 = weeding 2, 3 and 4 WAP. RFW = root fresh weight, RDW= root dry weight, SFW= shoot fresh weight, SDW = shoot dry weight, WAP: week after planting

Weeding time variations did not significantly affect the number of pods, filled pods, empty pods, seed weight, and seed weight per hectare (Table 9). The weed control at various timings and frequencies was not significantly differed in soybean yields (Table 9). The number of pods produced ranged from 30 to 42, similar to the Deja 1 soybean variety, which typically yields around 36 pods. Extensive weed presence in the experimental field hindered soybean pod filling, resulting in an increased number of empty pods. The highest soybean seed weight per hectare recorded was 0.79 tons. The yield was lower than the potential yield of the Deja 1 variety, which was 2.87 tons/ha. Weeding three times at 2, 3, and 4 weeks after planting (WAP) resulted in a seed weight of 0.73 tons/hectare. Weeds significantly reduced soybean yields when planted using water-saturated methods in coastal areas, by as much as 74.56%.

Table 9. Effect of weeding on soybean pod number and seed weight

Treatments	Variables				
	Pod number	Filled pod	Empty pod	Seed weight (g)	Seed weight (ton/Ha)
P_1	32.89	10.83	22.05	4.60	0.61
P_2	30.05	9.39	21.44	4.20	0.56
P_3	36.94	12.72	23.78	5.67	0.75
P_4	42.77	22.16	20.61	5.99	0.79
P_5	39.55	18.44	21.11	5.54	0.73
P_6	33.33	13.99	19.33	4.67	0.62
P_7	39.05	19.55	19.50	5.81	0.73

Note: P1 = weeding 2 WAP, P2 = weeding 3 WAP, P3 = weeding 4 WAP, P4 = weeding 2 and 3 WAP, P5 = weeding 2 and 4 WAP, P6 = weeding 3 and 4 WAP, P7 = weeding 2, 3 and 4 WAP, WAP: week after planting

Discussion

Weed observations indicated that *F. miliacea* was the predominant weed species at experimental site 2, 3, and 4 weeks after planting. This weed species was a sedge characterized by its upright growth and vigorous shoots, reaching a height of 60 cm. It thrives in wetlands which had a short germination time of about 7 days and was moderately competitive with intense root competition. With a year-long life cycle, it can produce several generations in one season and reproduced via seeds weighing only 0.02 mg. The plant had a flowering period of around 30 days and lacks a dormancy period (Caton *et al*., 2011). *F. miliacea* is highly adaptable to various environments and conditions and can be found in tropical and subtropical regions such as Australia, Bangladesh, India, Indonesia, Malaysia, Pakistan, the Philippines, and Thailand.

Weeds commonly found in soybean planting areas included *Echinochloa crus-galli*, *Cyperus rotundus*, *Eleusine indica*, *Echinochloa colona*, *Ageratum conyzoides*, *Cyperus iria*, *Phyllanthus urinaria*, *Alternanthera piloxeroides*, *Physalis angulata L.*, *Cynodon dactylon*, *Amaranthus spinosus L.*, *Leersia hexandra*, and *Dactyloctenium aegyptium*. According to (20), the dominant weed flora in soybean fields includes *Amaranthus viridis*, *Commelina benghalensis*, *Parthenium hysterophorus*, *Trianthema portulacastrum*, *Digera arvensis*, *C. dactylon*, *E. colona*, and *C. rotundus*.

Consistent with previous study, the findings from the study conducted under water-saturated conditions revealed the emergence of various weed types, including broad-leaved weeds, grasses, and sedges. These included *F. miliacea*, *C. sphacelatus*, *L. octovalvis*, *C. halpan*, *F. ciliaris*, *E. curtipedicellata*, *P. commersonii* Lamk., *G. divaricatum*, *S. compositus*, *P. repens*, and *Cyperus articulatus*. Weed identification was conducted both during critical growth stages and at harvest.

During harvesting, dominant weed species include *C. halpan* L., *F. miliacea*, *F. ciliaris*, and *C. sphacelatus* R., each with a Species Dominance Ratio (SDR) exceeding 10%. According to Caton *et al*. (2011), *C. halpan* L. is an allelopathic weed that grows upright in clumps, reaching heights of up to 0.8 m. It exhibited a moderate competitive ability, thrives in wetlands, germinates within seven days, reproduces via seeds and rhizomes, flowers 30 days after emergence, has seeds with a dormancy period, prefers full sunlight for germination, and can grow throughout the year up to an elevation of 1200 meters above sea level.

According to Moenandir (2010), *C. halpan* L. and *C. sphacelatus* are weeds that reproduce both vegetatively and generatively, making them challenging to manage. These weeds are allelopathic, meaning they produce secondary metabolites that inhibit the growth of surrounding plants. As repoted by Akbar

(2012), the dominance of these weeds is attributed to their high seed production and extensive dispersal capabilities, which complicates control efforts. *F. miliacea* and *F. ciliaris* are prolific seed producers with rapid growth rates, further complicating control measures. Research findings Kilkoda (2017) identify *Boreria alata*, *Mimosa pudica*, *Phyllanthus niruri*, and *A. conyzoides* as prominent broadleaf weeds in soybean fields. *E. indica*, *Paspalum conjugatum*, *E. crus-galli*, and *Axonopus compressus* are prevalent among grass species, while *Cyperus* spp. dominate the sedge group.

Weed dry weight at harvest increased significantly. According to Christia *et al*., 2016), higher weed dry weight indicates better growth and stronger competition against crops. Weed density plays a crucial role in determining weed dry weight. A dense weed population combined with a prolonged growing season will result in increased weed dry weight (Prayogo *et al*., 2017). Weeds growing alongside crops compete for nutrients, sunlight, water, and growing space, especially when these resources are limited. Without proper weeding practices, weeds can grow unchecked, significantly impacting crop growth (Zimdahl and Basinger, 2024; Zimdahl, 2004). The increase in weed dry weight might also be attributed to the moist soil conditions in water-saturated agriculture and the presence of weed seed banks. Weeds thrive in environments with high water and soil moisture levels, allowing them to flourish by producing more tillers and seeds, thereby dominating the experimental area. As noted in Paiman (2020) and Aisyah and Nugroho (2019), a seed bank refers to a reservoir of weed seeds in the soil, which can germinate and establish new weeds under favorable conditions. Weed seeds within the seed bank can remain viable for extended periods, even under harsh environmental conditions. Typically, weed seed bank density is highest within the top 0-5 cm of soil. The types of weeds present in the seed bank can often be identified by observing their resurgence following weed control measures.

The timing of weeding did not impact the growth and yield of soybeans grown in saturated soil conditions. This result is closely associated with the competition between soybeans and weeds. This study corroborates findings from (Nurjannah, 2003), highlighting that weeds in inundated areas impede plant growth due to their vigorous and rapid proliferation. Competition between weeds and soybeans after the final weeding at 4 WAP suppresses soybean growth.

As stated in Utami and Rahadian (2020), soybean growth is hindered by competition with weeds for essential resources such as water, nutrients, light, growing space, oxygen, and carbon dioxide, all crucial for photosynthesis. Shoot weight reflects the plant's uptake of water and nutrients, directly influencing its photosynthetic efficiency. Root weight indicates the water and nutrient reserves within the root tissue, reflecting the plant's overall metabolic activity in the roots.

Root length plays a significant role in determining root weight, as it correlates with the extent of nutrient and water absorption. Optimal availability of water and nutrients can lead to unhindered root development. According to Prasetyo and Hajoeningtias (2018), weeds have a higher demand for nutrients and water, which restricts soybean growth, especially at the root level where competition between soybean and weed roots intensifies.

Weed competition with soybeans reduces the rate of photosynthesis, leading to decreased storage of photosynthate in the seeds and a lower soybean seed weight (Lailiyah *et al*., 2014; Peer *et al*., 2013). As weed populations increase, plant growth becomes more stressed, resulting in fewer soybean pods being produced. Conversely, seed weight per hectare is influenced by both the number of pods and seeds (Widyatama *et al*., 2010). According to Aisyah and Nugroho (2019), a weed-free period in mineral-rich soil can enhance the number of pods and seeds per plant, as well as the weight of 100 seeds and the dry seed weight per hectare. The critical growth period for black soybeans like Mallika is between 2 and 6 weeks after planting, with crop losses ranging from 23.61% to 83.54% from early planting to harvest (Gultom *et al*., 2017).

In summary, the frequency and timing of weed control showed minimal impact on soybean growth and yield in water-saturated farming in coastal regions. Weeding once, twice, or three times did not significantly affect soybean growth or yield, except for influencing the number of leaves and branches. Dominant weeds at harvest included *C. halpan*, *F. miliacea*, *F. ciliaris*, and *C. sphacelatus* each with a Species Dominance Ratio (SDR) exceeding 10%. Mechanical methods for controlling weeds are ineffective in reducing weed infestation in water-saturated soybean cultivation. Therefore, alternative methods need to be explored to develop more effective weed control tools in tidal environments.

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(Received: 21 September 2024, Revised: 6 January 2025, Accepted: 10 January 2025)