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Sustainable Weed Management Using *Chromolaena odorata* Organic Mulch Improves Soybean Productivity

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Abstract
Weed management is commonly achieved through herbicide application; however, excessive herbicide use may lead to weed resistance and environmental degradation. This study aimed to determine the effective dose of organic siam weed (*Chromolaena odorata* L King and Robinson) mulch for suppressing weeds and improving soybean growth and yield. The experiment was conducted in Lawe Sagu Hulu Village, Lawe Bulan Subdistrict, Aceh Tenggara Regency, Aceh Province, from August to December 2024. A non-factorial randomized complete block design was used with five mulch doses: 0, 4.8, 9.6, 14.4, and 19.2 t ha^{-1}, each replicated four times. Experimental plots 2.5 × 2.5 m were prepared through standard tillage, and chopped siam weed mulch 10 cm was applied to the soil surface at planting according to treatments. Observed variables included root and plant fresh weight, weed control percentage, weed species number, weed fresh weight, seed weight, and 100-seed weight. Data were analyzed using SPSS version 16, and significant effects were further tested with Duncan's New Multiple Range Test. Application of 4.8 t ha^{-1} mulch improved weed control percentage 53.73 – 70.66%, while higher doses of 14.4–19.2 t ha^{-1} effectively reduced weed species number and weed fresh weight at 30 days after treatment, as well as increased root fresh weight at 40 days and soybean fresh weight at 20 and 40 days after treatment.

Keywords: Allelopathy, Germination, Organic matter, Soil moisture, Soil nutrients

1. Introduction

Weeds are undesirable plants that grow in cultivated fields and compete with soybean for essential resources such as light, water, nutrients, and growing space [1],[2]. This competition reduces the efficiency of resource utilization, thereby negatively affecting soybean growth and yield. In addition, weeds may serve as alternative hosts for pests and pathogens, and interfere with overall farming operations. Therefore, weed management is a crucial aspect of sustainable soybean production systems. The presence of weeds is particularly detrimental during the early growth stages, when soybean plants are still weak and unable to compete effectively [3]. The critical period of weed competition in soybean occurs between 20–50 days after planting (DAP), which strongly determines final yield [4]. Yield losses caused by weed interference in soybean can reach 56.90–66% if effective control measures are not applied, as reported in 2019–2020 [5], [6]. Hence, environmentally friendly and efficient weed management strategies are essential to ensure sustainable soybean cultivation.

Weed control is generally carried out mechanically and through herbicide application. However, excessive use of herbicides may cause weed resistance, environmental contamination, and potential risks to human health. Therefore, alternative approaches such as the application of organic mulch are required to provide more environmentally friendly and sustainable solutions. Organic mulch functions by covering the soil surface, thereby reducing light penetration necessary for weed photosynthesis and disrupting the germination process of weed seeds. According to, organic mulch contributes to maintaining soil moisture for water stability and availability [7], while its application can also enhance plant biomass [8]. One potential source of organic mulch is siam weed (*Chromolaena odorata* L King and Robinson), an invasive plant species containing allelopathy compounds such as flavonoids and phenols [9], [10]. These compounds are capable of inhibiting weed germination and growth. The use of siam weed as mulch not only suppresses weed growth physically but also biochemically through allelopathy effects. Weed responses to allelopathy are characterized by physiological changes, including leaf necrosis [11]. Allelopathy compounds interfere with protein synthesis, disrupt photosynthesis, and reduce chlorophyll pigments, ultimately causing leaf discoloration.

Furthermore, noted that siam weed biomass contains 20.26% organic matter, 0.55% N, a C/N ratio of 21.31, 0.13% P, 1.60% K, 0.49% Ca, and 0.29% Mg [12]. Similarly, reported its organic composition as 2.5% N, 0.35% P, 1.36% K, 1.98% Ca, and a pH of 6.67 [13]. Demonstrated that applying 10 t ha^{-1} of siam weed mulch improved soil quality parameters such as pH H_2O, organic carbon, cation exchange capacity, available N, P, K, Ca, and Mg, as well as tiller number, harvest dry weight, milling dry weight, and 1000-grain weight in rice compared to the control [14]. Similarly, reported that applying 24 t ha^{-1} of siam weed mulch increased pod number and seed yield in soybean [15]. In addition, found that mulch application at 1560–2600 g per 0.5625 m^2 (equivalent to 27.73–46.22 t ha^{-1}) enhanced plant height, tiller number, and leaf production in Brachiaria hybrid cv. Mulato [16]. Although several previous studies have demonstrated that Chromolaena odorata (kirinyuh) has potential as an organic material capable of improving soil fertility and crop productivity, information regarding the effectiveness of kirinyuh organic mulch in suppressing weed growth in soybean cultivation remains limited, particularly concerning the optimal application rate. Therefore, this study was conducted to determine the most effective dosage of kirinyuh organic mulch that not only suppresses weed growth but also enhances soybean growth and yield. The objective of this study was to determine the appropriate dose of siam weed organic mulch for suppressing weeds and improving the growth and yield of soybean.

2. Material and Methods

The experiment was conducted in Lawe Sagu Hulu Village, Lawe Bulan Subdistrict, Aceh Tenggara Regency, Aceh Province, from August to December 2024. The tools used included a measuring cylinder, hoe, raffia string, labeling paper, oven, and analytical balance. The materials consisted of soybean seeds of the Grobogan variety, siam weed litter, deltamethrin insecticide, urea, SP36, and KCl fertilizers. A non-factorial randomized complete block design (RCBD) was employed with five mulch application rates: D0 = 0 t ha^{-1}, D1 = 4.8 t ha^{-1}, D2 = 9.6 t ha^{-1}, D3 = 14.4 t ha^{-1}, and D4 = 19.2 t ha^{-1}. A non-factorial randomized complete block design (RCBD) was employed to control environmental variability among plots, such as topography, soil fertility, and moisture, and to evaluate the effect of mulch dosage alone without factorial interactions, ensuring accurate comparisons among treatments. Mulch rates were selected based on literature and field observations, ranging from no mulch to high doses feasible for field application, aiming to identify the optimal *Chromolaena odorata* dosage that effectively suppresses weed growth while enhancing soybean growth and yield, providing a clear assessment of crop responses and a scientific basis for field recommendations. In total, there were five treatments, each replicated four times.

Land preparation was carried out twice, followed by the construction of experimental plots measuring 2.5 × 2.5 m, with 30 cm spacing between treatments and replications, and 50 cm spacing between blocks. Planting was performed by creating holes 3 cm deep, each filled with three seeds at a spacing of 30 × 30 cm. The siam weed organic mulch, previously chopped into 10 cm pieces, was spread uniformly on the soil surface according to the assigned treatment at the time of planting. Fertilization was applied in two stages: at planting and 30 days after sowing (DAS), using urea, SP36, and KCl at rates of 70, 80, and 90 kg ha^{-1}, respectively; half of the urea was applied at planting together with the full rates of SP36 and KCl, while the remaining half of urea was applied at 30 DAS. Crop management included irrigation twice daily (morning and afternoon) and pest control using deltamethrin 2.5 EC at a concentration of 2 ml L^{-1} water. Harvesting was conducted at 83 DAS when approximately 95% of the soybean leaves had senesced. The observed variables were grouped into three categories: Weed growth characteristics: weed control percentage, weed species number, and weed fresh weight. The percentage of weed control was visually assessed by five evaluators by comparing weed growth in treated plots with that in control plots, using a rating scale from 0% (no control) to 100% (complete control). Weed species richness was determined by sampling weeds within 50 × 50 cm quadrats at four points per plot, and the total number of species was counted from all samples. Fresh weed biomass was measured by collecting weeds from the same quadrats, after which the samples were weighed to obtain total fresh biomass per plot. Soybean growth characteristics: root fresh weight and plant fresh weight. The fresh weight of roots and soybean plants was determined by collecting samples from 50 × 50 cm frames (four plants per frame) in each plot, after which the samples were weighed. Soybean yield characteristics: seed weight and 100-seed weight. Data were analyzed quantitatively using SPSS version 16. If significant treatment effects were detected, means were compared using Duncan's New Multiple Range Test (DNMRT). Descriptive analysis was also presented in tabular form.

3. Results and Discussion

3.1 Weed growth characteristics

The results showed that the application of 4.8 t ha^{-1} of siam weed organic mulch increased weed control percentage at 20, 30, 40, and 50 DAP. This effect was attributed to a combination of factors, including the allelopathy activity of the Siam weed mulch, which releases chemical compounds that inhibit seed germination and weed growth, the physical thickness of the mulch that restricts weed emergence, and the increased growth of soybean plants, which limits space and light availability for weeds. Higher mulch doses of 14.4–19.2 t ha^{-1} significantly reduced the number of weed species at 30 DAP as well as weed fresh weight. The reduction in weed cover percentage also indicated a shift in weed community structure, which was characterized not only by the decline in the dominance of certain species but also by changes in the ecological composition of the weed community. This finding was supported by a decrease in the Importance Value Index (IVI) of several dominant weed species in soybean fields. The decline in weed species richness may be attributed to the disruption of physiological and metabolic processes, particularly photosynthesis and seed germination, due to the allelopathy effects of siam weed mulch. Such effects impair root and leaf development in germinating weed seeds. According to allelopathy inhibition of germination is often characterized by shortened or absent primary roots, lack of secondary roots, swollen and stunted hypocotyls, malformations, lesions, or splitting of plant tissues, and decayed or deformed cotyledons [17]. Similarly, reported that allelopathy suppresses early seedling growth, including chlorophyll development, shoot elongation, and root growth [18]. Further demonstrated that allelopathy activity could reduce weed seed germination by up to 75.17% and exert negative effects on initial seedling establishment [19].

Table 1 Mean percentage of weed control, number of weed species, and weed fresh weight on 20, 30, 40, 50 DAP as affected by different doses of siam weed organic mulch

Treatment	Percentage of Weed Control			
	20	30	40	50
Dose of Mulch	---------------------------------- % ----------------------------------			
0 t ha^{-1}	8.50a	5.25a	1.60a	0.00a
4.8 t ha^{-1}	70.66b	62.25b	63.75b	53.73b
9.6 t ha^{-1}	71.83b	67.75b	60.25b	56.33b
14.4 t ha^{-1}	81.91b	62.75b	60.75b	51.99b
19.2 t ha^{-1}	81.33b	64.25b	66.50b	58.24b
	Number of Weed Species			
	20	30	40	50
	---------------------------------- ----------------------------------			
0 t ha^{-1}	10.75	9.50a	8.00	6.75
4.8 t ha^{-1}	6.75	8.25ab	6.50	7.50
9.6 t ha^{-1}	7.00	6.75abc	6.00	7.00
14.4 t ha^{-1}	5.25	6.50bc	6.50	6.75
19.2 t ha^{-1}	7.50	5.00c	7.75	6.00
	Weed Fresh Weight			
	20	30	40	50
	---------------------------------- g ----------------------------------			
0 t ha^{-1}	124.03	136.29a	166.19	207.26
4.8 t ha^{-1}	66.53	62.38b	102.59	221.39
9.6 t ha^{-1}	55.50	87.67ab	119.80	205.42
14.4 t ha^{-1}	50.46	49.77b	127.84	171.07
19.2 t ha^{-1}	37.87	89.77ab	105.39	193.15

The numbers followed by the same letter in the same column are not significantly different in Duncan's 5% test

In addition, the persistence of weed seed dormancy in the soil seed bank depends on species, and germination may occur once environmental conditions become favorable [20]. Stated that the competitive ability of weeds in capturing light and nutrients can restrict crop growth [21]. Furthermore, it was emphasized that weed competition in soybean cultivation is also influenced by the crop's competitive capacity as well as the abundance and diversity of associated weed species [22]. This explains the observed reduction in weed cover, species diversity, and population density under mulch treatments. The application of 4.8 t ha^{-1} of siam weed mulch effectively increased weed control percentage, reduced weed cover, and lowered weed population at 20 DAP. Furthermore, higher doses of 14.4–19.2 t ha^{-1} significantly decreased weed fresh weight and weed species richness at 20 and 30 DAP [23].

3.2 Soybean growth characteristics

Table 2 Mean root and shoot fresh weight of soybean on 20, 30, 40, 50 DAP as affected by weed management with different doses of siam weed organic mulch

Treatment	Root Fresh Weight			
	20	30	40	50
Dose of Mulch	g			
0 t ha^{-1}	0.61	0.81	0.94ab	1.93
4.8 t ha^{-1}	0.46	0.88	0.80a	2.64
9.6 t ha^{-1}	0.69	1.56	1.12ab	1.93
14.4 t ha^{-1}	0.73	1.32	1.55bc	1.79
19.2 t ha^{-1}	0.91	1.55	2.08c	3.46
	Shoot Fresh Weight			
	20	30	40	50
	g			
0 t ha^{-1}	2.03a	4.96	3.62a	47.01
4.8 t ha^{-1}	3.37ab	5.07	7.31ab	45.46
9.6 t ha^{-1}	3.67ab	5.39	13.85ab	46.14
14.4 t ha^{-1}	4.72b	7.62	22.37b	48.90
19.2 t ha^{-1}	5.59b	9.30	20.32b	59.33

The numbers followed by the same letter in the same column are not significantly different in Duncan's 5% test

The results showed that the application of siam weed mulch at 14.4–19.2 t ha^{-1} significantly increased root fresh weight at 40 DAP as well as plant fresh weight at 20 and 40 DAP. The increase in root and shoot biomass indicates that siam weed mulch plays an important role in supporting soybean growth, as reflected by greater leaf size, stem diameter, and root development. This is in line with reported that siam weed contains high levels of organic matter that improve soil chemical properties such as pH, exchangeable Al, available P, total N, and exchangeable K [24]. Further emphasized that thicker mulch layers ensure better soil moisture retention and enhance organic matter decomposition, thereby increasing nutrient availability [25]. Similarly, found that siam weed mulch contains up to 82.3% organic matter, contributing significantly to improved plant growth [26], also reported that 14.4 t ha^{-1} of siam weed mulch enhanced plant height during the 20–40 DAP period and increased plant fresh weight up to 50 DAP, while 19.2 t ha^{-1} mulch promoted root fresh weight as early as 20 DAP [4]. Overall, these findings suggest that higher doses of siam weed mulch not only suppress weed populations but also enhance soil fertility and contribute to increased soybean growth and productivity.

3.3 Soybean yield characteristics

Table 3 Mean seed weight and 100-seed weight of soybean as affected by weed management with different rates of siam weed organic mulch

Treatment	Seed Weight	100-Seed Weight
Dose of Mulch	g	
0 t ha^{-1}	6.48	21.47
4.8 t ha^{-1}	10.18	28.30
9.6 t ha^{-1}	14.79	23.55
14.4 t ha^{-1}	9.47	23.28
19.2 t ha^{-1}	30.88	25.25

The results indicated that the application of siam weed organic mulch did not significantly increase seed weight and 100-seed weight of soybean. This can be explained by the fact that weed suppression by siam weed mulch was effective only from planting up to 50 DAP, as reflected in the higher weed control percentages (Table 1). Dry seed yield is strongly influenced by reduced weed growth and the availability of essential nutrients required for seed formation [27]. The suppression of weed growth achieved through uniform application of relatively high mulch rates limited the space and resources available for weeds, thereby enhancing soybean growth, as evidenced by increased root and shoot biomass (Table 2). However, by 50 DAP, the siam weed mulch had decomposed, reducing its capacity to suppress weed populations. This stage coincides with the critical reproductive phase of soybean, when adequate nutrient supply is essential for flower initiation, pod formation, and seed development [28]. Based on observations of weed control percentage, species composition, and weed biomass, the most effective rate was found at 19.2 t ha^{-1}. Nevertheless, this rate appears to approach a selective threshold, which may explain why seed weight and 100-seed weight did not show significant statistical differences, remaining relatively similar across treatments.

4. Conclusion

The application of siam weed organic mulch at 4.8 t ha^{-1} increased the percentage of weed control 53.73 – 70.66%. Higher mulch rates of 14.4–19.2 t ha^{-1} reduced weed species diversity at 30 DAP, decreased weed fresh weight at 30 DAP, and enhanced root fresh weight at 40 DAP as well as soybean plant fresh weight at 20 and 40 DAP.

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References

[1]. Imoloame, E.O. (2014). The effects of different weed control methods on weed infestation, growth and yield of soybeans (*Glycine max* (L) Merril) in the Southern Guinea Savanna of nigeria. *Agrosearch,* 14(2), 129–143.

[2]. Ramut, A., Untari, Y., Pani, M., Abdi, Z. (2024). Karakteristik gulma akibat variasi dosis herbisida oxyfluorfen di pertanaman kedelai. *J Pertan Agros*, 26(4), 1716–1721.

[3]. Untari, Y., & Ramut, A. (2023). Pengaruh herbisida oxyfluorfen terhadap pertumbuhan tanaman kedelai (*Glycine max* (L.) Merril). *Fanik J Faperta Uniki*, 4(2), 34–37.

[4]. Ramut, A., Harta, R.Y., Pani, M., Sitinjak, L., Mahfirah, A. (2025). Variasi dosis mulsa organik akasia dan kirinyuh dalam mengendalikan gulma pada tanaman kedelai : studi karakteristik pertumbuhan tanaman kedelai. *Agrosustain,* 3(1), 26–31.

[5]. Daramola, O.S., Adeyemi, O.R., Adigun, J.A., Adejuyigbe, C.O. (2022). Influence of row spacing and weed control methods on weed population dynamics in soybean (*Glycine max* L.). *Int J Pest Manag*, 68(1), 43–58.

[6]. Khaffagy, A.E., Mazrou, Y.S.A., Morsy, A.R., El-Mansoury, M.A.M., El-Tokhy, A.I., Hafez, Y., et al. (2022). Impact of irrigation levels and weed control treatments on annual weeds, physiological traits and productivity of soybean under clay soil conditions. *Agronomy,* 12(5),1037.

[7]. Kurniawan, H., Yuniasih, B., Mu'in, A. (2023). Pengaruh macam dan ketebalan mulsa terhadap pertumbuhan gulma dan bibit kelapa sawit di pre nursery. *Agroforetech,* 1(3), 1633–1637.

[8]. Wibowo, M.A. (2010). Strateg penggunaan Em-4, mulsa jerami dan sekam terhadap pertumbuhan dan hasil tanaman kedelai hitam (*Glycine soja*) pemasaran tiwul instan studi kasus di PT Sinar Sukses

Sentosa Kabupaten Gunung Kidul Daerah Istimewa Yogyakarta. Skripsi Fakultas Pertanian Universitas Sebelas Maret. Surakarta.
[9]. Kato-Noguchi, H., & Kato, M. (2023). Evolution of the secondary metabolites in invasive plant species Chromolaena odorata for the defense and allelopathy functions. *Plants*, *12*(3), 521.
[10]. Nyong, A., & Nworgu, C. O. (2023). Effects of siam weed (*Chromolaena odorata*) on plant parasitic nematodes on tomatoes (*Solanum lycopersicum*). *Faculty of Natural and Applied Sciences Journal of Scientific Innovations*, *4*(1), 193-197.
[11]. Rosyada, S. A. (2023). Uji alelokimia babandotan (*Ageratum conyzoides*) sebagai bioherbisida terhadap vegetasi gulma perkebunan jeruk purut (*Citrus hystrix*). Skripsi Fakultas Sains dan Teknologi Universitas Islam Negeri Maulana Malik Ibrahim. Malang.
[12]. Akinrinola, T. B., & Tijani-Eniola, H. (2022). The influence of Siam weed compost and inorganic fertiliser applications on tomato performance. *Journal of Agricultural Sciences, Belgrade*, *67*(3), 219-235.
[13]. Jaiman, R., Temu, S.T., Osa, D.B. (2025). Pengaruh ketebalan mulsa organik kirinyuh (*Chromolaena odorata*) terhadap produksi bahan segar, bahan kering dan bahan organik rumput gajah mini (*Pennisetum purpureum* cv. Mott). *Anim Agricultura*, 3(1), 943–951.
[14]. Suntoro., Herdiansyah, G., Mujiyo., Widijanto, H., Maroeto., Julianto, E.A., et al. (2024). Potential of *Chromolaena odorata*, *Ipomoea carnea* and *Eichhornia crassipes* as green manures on soil fertility index and rice production on vertisols. *J Arid Agric*ultura, 10, 32–34.
[15]. Hasanuddin., Hafsah, S., Nurahmi, E., Migawati, S.W., Bobihoe, J., Aryani, D.S. (2021). The application of different mulches and its effect on soybean yield. In: IOP Conference Series: Earth and Environmental Science. 21-22 September 2020, Banda Aceh, Indonesia. p. 1–5.
[16]. Kore, M.J.T., Nastiti, H.P., Osa, D.B. (2024). Pengaruh ketebalan mulsa organik kirinyuh (*Chromolaena odorata*) terhadap pertumbuhan rumput mulato (*Brachiaria hybrid* cv. Mulato). *Anim Agricultura,* 2(1), 340–734.
[17]. Jilli, A.Q.A., Indarwati, I., Susilo, A., Surjaningsih, D.R. (2023). Potensi alellopati ekstrak gulma alang alang sebagai bioherbisida. *J Appl Plant Technol JAPT,* 2(1), 30–41.
[18]. Susilo, B.S.M., Indarwati I., Susilo, A. (2024). Allelopathy test of reeds (*Imperata cylindrica*) on germination and early growth of green beans (*Vigna radiata* L). *J Appl Plant Technol*, 3(1), 1–10.
[19]. Amrullah, R. (2024). Uji alelopati ekstrak teki (*Cyperus rotundus*) pada perkecambahan dan pertumbuhan awal gulma bayam duri (*Amaranthus spinosus*). Skripsi Program Studi Agroteknologi Fakultas Pertanian Universitas Wijaya Kusuma Surabaya.
[20]. Umami, W., Lubis, I.M., Nurhajijah. (2023). Uji efektivitas dosis bubur sambung rambat dalam mengendalikan gulma melalui pengamatan summed dominance ratio di pembibitan utama kelapa sawit. *Radikula J Ilmu Pertan*ian, 2(2), 69–75.
[21]. Horneburg, B., Seiffert, S., Schmidt, J., Messmer, M.M., Wilbois, K., Singh, R. (2017). Weed tolerance in soybean: a direct selection system. *Plant Breed,* 136 (3), 372–378.
[22]. Faqihhudin, M.D. (2014). Efek samping penggunaan herbisida ipa-glifosat terhadap pertumbuhan, hasil, danresidu pada jagung.Tesis Sekolah Pascasarjana Institut Pertanian Bogor. Bogor.
[23]. Ramut, A., Harta, R.Y., Pani, M., Maida. (2025). Variasi dosis mulsa organik akasia dan kirinyuh dalam mengendalikan gulma pada tanaman kedelai: studi karakteristik pertumbuhan gulma. *J Pertanian Agros,* 27(1), 47–54.
[24]. Syofiani, R., & Islami, S. (2021). Pengaruh berbagai dosis kompos kirinyuh (*Chromolaena odorata*) terhadap sifat kimia tanah dan hasil tanaman jagung (*Zea mays* L.). *J Agrium,* 18(1), 52–56.
[25]. Lodo, D.F., Osa, D.B., Sulistijo, E.D. (2022). Pengaruh ketebalan mulsa organik kirinyuh (*Chromolaena odorata*) terhadap kandungan nutrisi rumput *Brachiaria hybrid* cv. Mulato panen ke-3. *J Peternakan Lahan Kering*, 4(4),
[26]. Smith, M.A.K., & Onamadi, M.D. (2021). Effects of residue mulch on weed growth, pod yield and nutrient contents in okra (A*belmoschus esculentus*) in the humid tropical zone of southwestern nigeria. *J Sustain Technol*, 11(1):79–88.
[27]. Ramut, A., Harta, R.Y., Pani, M., Sitinjak, L., Gunawiati, T.P. (2025). Variasi dosis mulsa organik akasia dan kirinyuh dalam mengendalikan gulma pada tanaman kedelai : studi karateristik hasil tanaman kedelai. *Agrosustain,* 3(1), 11–16.
[28]. Ramut, A., Untari, Y., Sitinjak, L., Sumoharjo, D., Nasrullah. (2023). Karakteristik hasil tanaman kedelai akibat variasi dosis herbisida oxyfluorfen. *Agrosustain,* 1(2):45–49.