Application of oxyfluorfen and pendimethalin to control weeds on soybean plantation

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Abstract. The appearance of weeds on crops has led to the significant loss of crop yield. Therefore, chemical control with herbicides has been an important tool for rapid and efficient weed management in crops. The objective of this study was to evaluate the effect of herbicides oxyfluorfen and pendimethalin against weeds on soybean plantation. This research employed Randomized Completely Block Design (RCBD) Factorial with 2 factors. The first factor was the type of herbicides: oxyfluorfen and pendimethalin. The second factor was herbicide doses: 0, 500, 1000, 1500 and 2000 g a.i ha⁻¹, applied on soybean at 1 day after planting (DAP). The percentage of weed control, percentage of weed coverage, weed species, weed population, and weed dry weight were observed at 3, 5, 7 and 9 weeks after planting (WAP). The results revealed that different types and doses of herbicide applied has affected the percentage of weed control, percentage of weed coverage weed species and weed dry weight.

1. Introduction
Herbicides are chemical substance to control or inhibit the growth of undesirable plants without harming the desirable crops. Hakim et al [1] and Farhoudi and Hamze [2] stated that there are several factors affecting the success of herbicide application in controlling weeds, for instance the doses of herbicides. The application of lower doses of herbicides has caused herbicides to be less effective. Tehranchian et al [3] exhibited that the higher dose of herbicide applied has caused weeds to be more susceptible due to high amounts of active compounds of herbicides absorbed by weeds. Oxyfluorfen and pendimethalin are generally used as pre-emergence chemicals on soybean plantation. Priya et al [4] reported that broad-leaved weeds were effectively controlled by oxyfluorfen. Permana et al [5] found that the use of oxyfluorfen 1500 g a.i ha⁻¹ significantly suppressed the growth of weeds reached up to 67%. Pendimethalin is one of soil-applied herbicides which used as pre-emergence herbicide [6]. Research of Hasanuddin [7] reported that application of pendimethalin 750 -1500 g a.i ha⁻¹ has increased the percentage of weed control.

The changes in weed compositions due to application of different herbicides with different doses can be observed by calculating the percentage of weed control, the percentage of weed coverage,..
number of weed species and weed population in an area. The significant changes occur when herbicides are applied [8]. This result is in line with the research of Sebayang et al [9]. They revealed that there was a change in weed dominance due to herbicide application and weeding. The purpose of this study was to investigate the weed characteristics associated with application of different doses of oxyfluorfen and pendimethalin.

2. Materials and methods

2.1. Place and duration
This research was conducted in Rumpeet Village, Krueng Barona Jaya Sub district, Aceh Besar District. The herbicides were applied right after planting soybeans. Variables observed were weed control percentage, percentage of weed coverage, number of weed species, weed population, and weed dry weight at 3, 5, 7 and 9 weeks after planting (WAP) and weed dry weight was obtained by weighing the weeds at Weed Management Laboratory, Universitas Syiah Kuala, Banda Aceh from March to June 2019.

2.2. Equipments and materials
Equipments used in this research were handtractor, measuring tapes, buckets/pails, hoes, watering cans, knapsack sprayer 15 L, frame 50 cm x 50 cm, 3 ml syringe, label stickers, analytical balance, and oven. Materials used in this research were soybean seeds var. Devon 1, herbicides oxyfluorfen and pendimethalin, urea, SP36 and KCl fertilizers, and insecticides carbofuran and deltamethrin.

2.3. Data analysis
This research used Randomized Completely Block Design (RCBD) Factorial with 2 factors replicated 2 times. The first factor was the herbicides: oxyfluorfen and pendimethalin, and the second factor was the doses of herbicides: 0, 500, 1000, 1500 and 2000 g a.i ha⁻¹. Analysis of Variance was utilized to analyse the data. Significant means were performed using Duncan’s New Multiple Range Test (DNMRT) at probability level of 0.05

3. Results and discussions

3.1. Weed control percentage
The results revealed that application of different herbicides did affect the weed control at 3, 5 and 7 WAP. Also, different doses of herbicides gave significant result to weed control percentage at 3, 5, 7 and 9 WAP. There was an interaction between types and doses of herbicides on weed control percentage at 3 and 9 WAP (Tables 1 and 2). The application of oxyfluorfen has reduced the weeds up to 64%. Frans and Talbert [10] reported that oxyfluorfen gave moderate effect to weeds. The application of oxyfluorfen has caused disruption in physiological activity of weeds or germinating weeds. Tjitrosoedirdjo et al [11] also revealed that the application of oxyfluorfen can damage the cell walls which disrupt enzymatic activities in weeds resulted in abnormal growth of weeds. The results in Table 2 showed that oxyfluorfen 1500 g a.i ha⁻¹ has controlled the weeds reached up to 89.47%. The high percentage of weed control illustrated high amount of herbicide has been absorbed by weed roots or by other organs of weeds that susceptible to herbicide exposure. This herbicide absorption affected photosynthesis activity weeds resulted in abnormal growth and development of weeds. This finding supported the research of Umiyati [12] who investigated that the application of oxyfluorfen 1200 to 3600 g a.i ha⁻¹ successfully controlled several dominant weeds in paddy rice field respectively.
Table 1. Percentage of weed control due to application of different types and doses of herbicides.

| Treatments | 5 WAP | 7 WAP | 9 WAP |
|------------|-------|-------|-------|
| Herbicides |       |       |       |
| Oxyfluorfen| 38.47 b | 44.27 b | 51.31 |
| Pendimethalin | 24.39 a | 23.77 a | 57.07 |
| doses (g a.i ha\(^{-1}\)) |  6.23 a | 777 a | 12.47 a |
| 0 | 43.27 c | 43.67 b | 58.13 b |
| 500 | 28.33 b | 36.50 b | 66.90 b |
| 1000 | 37.53 bc | 42.37 b | 61.50 b |
| 1500 | 41.77 bc | 39.80 b | 61.50 b |

Values followed by the same letters (vertical lowercase letters and horizontal uppercase letters) do not differ significantly as determined by Duncan’s New Multiple Range Test (α = 0.05).

Table 2. The percentage of weed control at 3 and 9 WAP due to interaction between different types and doses of herbicides.

| Types of herbicides | Percentage of weed control at 3 WAP (%) | Doses (g a.i ha\(^{-1}\)) |
|---------------------|----------------------------------------|---------------------------|
|                     | 0 | 500 | 1000 | 1500 | 2000 |
| Oxyfluorfen         | 5.40 aA | 62.80 aB | 74.27 aBC | 89.47 bC | 88.07 bC |
| Pendimethalin       | 9.73 aA | 60.53 aB | 66.53 aB | 52.60 aB | 67.67 aB |

| Types of herbicides | Percentage of weed control at 9 WAP (%) | Doses (g a.i ha\(^{-1}\)) |
|---------------------|----------------------------------------|---------------------------|
|                     | 0 | 500 | 1000 | 1500 | 2000 |
| Oxyfluorfen         | 11.87 aA | 66.60 aBC | 57.87 aB | 65.33 aBC | 83.67 bC |
| Pendimethalin       | 13.07 aA | 77.27 aC | 58.40 aBC | 68.47 aC | 39.33 aB |

Values followed by the same letters (vertical lowercase letters and horizontal uppercase letters) do not differ significantly as determined by Duncan’s New Multiple Range Test (α = 0.05).

3.2. Percentage of weed coverage
The results in Table 3 exhibited that the usage of different herbicides exposed significant difference to percentage of weed coverage. Those significant differences were found at 5 and 7 WAP. Also, different doses of herbicide affected the percentage of weed cover. This effect was found at 3 and 7 WAP. In this research, oxyfluorfen showed the ability of reducing the percentage of weed coverage on soybean (Tables 3 and 4). Oxyfluorfen, a broad-spectrum pre-emergence herbicide has ability to inhibit the weed growth and caused the death of weeds. Erida [13] confirmed that higher dose of herbicide contributed to lower weed coverage.
Table 3. Percentage of weed coverage due to application of different types and doses of herbicides.

| Treatments          | Percentage of weed coverage (%) |
|---------------------|---------------------------------|
|                     | 5 WAP  | 9 WAP  |
| Types of herbicides |        |        |
| Oxyfluorfen         | 60.11 a| 44.32  |
| Pendimethalin       | 78.79 b| 49.88  |
| Doses (g a.i ha⁻¹)  |        |        |
| 0                   | 89.80 b| 82.97 b|
| 500                 | 62.17 a| 34.00 a|
| 1000                | 68.77 a| 44.30 a|
| 1500                | 65.07 a| 35.90 a|
| 2000                | 61.43 a| 38.33 a|

Values followed by the same letters in the same columns do not differ significantly as determined by Duncan’s New Multiple Range Test (α = 0.05)

Table 4. Percentage of weed coverage at 3 and 7 WAP due to interaction between different types and doses of herbicides.

| Herbicides          | Percentage of weed coverage at 3 WAP (%) |
|---------------------|----------------------------------------|
|                     | 0  | 500 | 1000 | 1500 | 2000 |
| Oxyfluorfen         | 88.67 aC | 37.60 aB | 28.33 aAB | 7.67 aA | 13.07 aAB |
| Pendimethalin       | 74.67 aC | 34.40 aB | 33.07 aB | 51.33 bBC | 29.47 aA |

| Herbicides          | Percentage of weed coverage at 7 WAP (%) |
|---------------------|----------------------------------------|
|                     | 0  | 500 | 1000 | 1500 | 2000 |
| Oxyfluorfen         | 89.13 aB | 42.60 aA | 45.33 aA | 36.80 aA | 28.80 aA |
| Pendimethalin       | 84.73 aB | 57.13 aA | 71.33 bAB | 63.27 bAB | 75.40 bAB |

Values followed by the same letters in the same columns do not differ significantly as determined by Duncan’s New Multiple Range Test (α = 0.05)

Results in the tables indicated that higher doses given demonstrated lower percentage of weed coverage. Oxyfluorfen 1500 g a.i ha⁻¹ has reduced the percentage of weed coverage (7.67%) (Table 4). This is similar to the result of Permana et al [5] who investigated that the application of oxyfluorfen 1500 g a.i ha⁻¹ strongly suppressed the weed growth. This herbicide poisons the plant cells, resulted in respiration and photosynthesis inhibition [14]. These inhibitions do not only caused a failure in cell division and its development, but also disruption of energy production translocation in meristematic cells located at the tips of roots and stems.

3.3. Weed species

The results given in Table 5 presented the effect of different types and doses of herbicides to weed species. The application of oxyfluorfen has deteriorated the number of weed species. It is due to this herbicide has ability to destroy germinating weeds, resulted in failure of weeds to grow and to develop normally. Oxyfluorfen has inhibited the germination, growth and development of meristematic tissues [15]. The results also have shown that herbicides 1500 g a.i ha⁻¹ has decreased the weed species. Several previous research also reported that the application of pendimethalin 900-2000 g a.i ha⁻¹ has controlled annual grassy and broadleaved weeds [16, 17].
Table 5. Number of weed species due to application of different types and doses of herbicides.

| Treatments | Weed species |
|------------|--------------|
|            | 3 WAP | 5 WAP | 7 WAP | 9 WAP |
| **Herbicides** |       |       |       |       |
| Oxyfluorfen | 3.13  | 3.87  | 3.67  | 3.53 a|
| Pendimethalin| 3.87  | 4.60  | 4.13  | 4.80 b|
| **Doses (g a.i ha$^{-1}$)** |       |       |       |       |
| 0          | 5.33 c | 6.83 c | 6.50 c | 6.17 b|
| 500        | 4.33 bc| 4.17 a | 4.50 b | 4.00 a|
| 1000       | 3.33 ab| 4.83 b | 3.50 ab| 4.17 a|
| 1500       | 2.17 a | 2.83 a | 2.67 ab| 3.50 a|
| 2000       | 2.33 a | 2.50 a | 2.33 a | 3.00 a|

Values followed by the same letters in the same columns do not differ significantly as determined by Duncan’s New Multiple Range Test ($\alpha = 0.05$)

3.4. Weed population

The results presented in Table 6 described the doses of herbicides affecting the weed population. Herbicides 500–2000 g a.i ha$^{-1}$ significantly decreased the population of weeds compared to control. It indicated that an increasing of doses attributed to lower growth of weeds and also it decreased the competition between these undesirable plants with the crops. As a result, the population of these unwanted plants has decreased. Lati et al [18] found that the application of pendimethalin has reduced the weed density from 260 to 103 populations. Surprisingly, the lower dose of pendimethalin can be applied when the weed density is higher.

Table 6. Weed population due to application of different types and doses of herbicides.

| Treatments | Weed population |
|------------|-----------------|
|            | 3 WAP | 5 WAP | 7 WAP | 9 WAP |
| **Herbicides** |       |       |       |       |
| Oxyfluorfen | 25.87 | 43.07 | 39.20 | 40.47 |
| Pendimethalin| 32.20 | 51.67 | 45.00 | 40.67 |
| **Doses (g a.i ha$^{-1}$)** |       |       |       |       |
| 0          | 48.83 b | 69.50 b | 56.83 b | 57.33 b|
| 500        | 26.17 a | 41.33 a | 35.50 a | 29.67 a|
| 1000       | 24.50 a | 43.00 a | 41.50 a | 41.67 a|
| 1500       | 23.00 a | 42.17 a | 37.67 a | 37.00 a|
| 2000       | 22.67 a | 40.83 a | 39.00 a | 37.67 a|

Values followed by the same letters in the same columns do not differ significantly as determined by Duncan’s New Multiple Range Test ($\alpha = 0.05$)

3.5. Weed dry weight

The results showed that the application of different herbicides did affect the dry weight of weeds at 5 and 7 WAP. The application of different doses exposed the effect to weed dry weight at 5 and 9 WAP. The results have proven that oxyfluorfen was more effective in reducing dry weight of weeds compared to pendimethalin (Table 7). The finding is in line with the research of Perkasa [19] who evaluated that oxyfluorfen was more effective in controlling weeds.

The application of herbicides with different doses 500–2000 g a.i ha$^{-1}$ has decreased the dry weight of weeds respectively (Table 7). The higher doses given; it inhibited the growth of weeds which
caused lower dry weight. Erida [13] reported that the application of pendimethalin 750 -2250 g a.i ha\(^{-1}\) has reduced the dry weight of weeds.

Table 7. Weed dry weight due to application of different types and doses of herbicides.

| Treatments | Weed dry weight (g) |
|------------|---------------------|
|            | 3 WAP | 5 WAP | 7 WAP | 9 WAP |
| Herbicides |        |       |       |       |
| Oxyfluorfen| 7.09  | 15.79 a | 35.13 a | 38.11 |
| Pendimethalin | 10.14 | 21.03 b | 52.86 b | 43.92 |
| Doses (g a.i ha\(^{-1}\)) |        |       |       |       |
| 0          | 11.13 | 30.68 b | 49.46 | 55.25 c |
| 500        | 5.61  | 13.70 a | 38.88 | 25.03 a |
| 1000       | 6.23  | 15.17 a | 44.98 | 47.40 bc |
| 1500       | 11.76 | 17.48 a | 41.30 | 33.94 ab |
| 2000       | 8.36  | 15.02 a | 45.41 | 43.45 bc |

Values followed by the same letters in the same columns do not differ significantly as determined by Duncan’s New Multiple range Test (\(\alpha = 0.05\))

4. Conclusion
The application of different herbicides and its different doses affected the percentage of weed control, percentage of weed coverage, weed species and dry weight of weeds. The higher dose of herbicide applied, the higher the percentage of weed control and the lower the percentage of weed coverage, weed species weed population, and dry weight of weeds. There was an interaction between types and doses of herbicides to percentage of weed control at 3 and 9 WAP and percentage of weed coverage at 3 and 7 WAP.

References
[1] M A Hakim, A S Juraimi, S M R Karim, M S I Khan, M S Islam, M K Choudhury, W Soufan, A Alharby, A Bamagoos, M A Iqbal, F Hnilicka, J Kubes, M H Ur Rahman, S Saud, M M Hassan and A L Sabagh 2021 Effectiveness of herbicide to control rice weeds in diverse saline environments Sustainability 13 1-12.
[2] R Farhoudi and M Hamze 2018 Effect of tank mixing herbicides on mung bean (Vigna radiate) grain yield and weed control at North Khuzestan climatic condition. Iranian Journal Pulses Research 9 151-165.
[3] P Tehranchian, J K Norsworthy, S Powles, M T Bararpour, M V Bagavathiannan, T Barber and R C Scott 2017 Recurrent sublethal-dose selection for reduced susceptibility of Palmer amaranth (Amaranthus palmeri) to dicamba. Weed Science 65 206-212.
[4] R S Priya, C Chinnasamy, P M Arthanari and P Janaki 2017 Pre-emergence herbicide of oxyfluorfen on weed control in transplanted rice International Journal of Chemical Studies 5 271-275.
[5] J Permana, W Eko and P J Kurniawan 2018 Penggunaan herbisida oksifluorfen dan pendimethalin pada tanaman bawang merah (Allium ascalonicum L.) Jurnal Produksi Tanaman 6 561-568.
[6] Baidhawi 2013 Degradasi herbisida pendimethalin pada tanah yang berbeda kandungan bahan organik Jurnal Agribisnis dan Pengembangan Wilayah. 4 21-30.
[7] Hasanuddin 2012 Aplikasi herbisida clomazone dan pendimethalin pada tanaman kedelai kultivar Argomulyo: I. Karakteristik gulma Jurnal Agrista 16 1-6.
[8] V S Rao 2000 Principles of Weed Science, 2nd Ed. (Science Publisher Inc/Enfield NH).
[9] H T Sebayang, S Soekartomo, Y Widodo and H Umar 2003 Pengaruh pengendalian gulma terhadap pertumbuhan dan hasil tanaman kacang tanah yang ditanam pada berbagai jarak tanam ubi kayu Jurnal Gulma Tropika 1 54-63.
[10] O Frans and F Talbert 1977 Research Methods in Weed Science Edition (USA: Department of Agronomy University of Arkansas/Fayetteville Arkansas)
[11] S Tjitrosoedirdjo, I H Utomo and J Wiroatmodjo 1984 Pengelolaan Gulma di Perkebunan (Ind: Gramedia/Jakarta).
[12] U Umiyati 2016 Efikasi herbisida oksifluorfen 240 g/l untuk mengendalikan gulma pada budidaya padi sawah (Oryza sativa L) Kulitivasi. 15 128-132.
[13] G Erida 2005 Aplikasi herbisida pendimethalin serta pengaruhnya terhadap pertumbuhan gulma pada tanaman kedelai Jurnal Agrista 9 254-259.
[14] W N Lailiyah, E Widyayanto and K P Wicaksono 2014 Pengaruh periode penyiangan gulma terhadap pertumbuhan dan hasil tanaman kacang panjang (Vigna sesquipedalis L) Jurnal Produksi Tanaman 2 606-612.
[15] J Moenandir 1990 Fisiologi Herbisida . (Ind: C.V. Rajawali/Jakarta).
[16] A S Cullpepper and A C York 2000 Weed Management. pp. 280-301. In R E L Naylor (ed.) Weed Management Handbook. 9th. (UK: Blackwell Science Ltd/Oxford).
[17] B E Tharp and J J Kells 2000 Effect of soil-applied herbicides on establishment of cover crop species. Weed Technology 14 596-601.
[18] R N Lati, B Mou, J S Rachuy, R F Smith, S K Dara, O Daugovish and S A Fennimore 2015 Weed management in transplanted lettuce with pendimethalin and s-metolachlor Weed Technology 29 827-834.
[19] A Y Perkasa 2015 Studi Pengendalian Gulma dengan Menggunakan Herbisida pada Budidaya Kedelai Jernih Air di Lahan Pasang Surut Tesis Program Pascasarjana Institut Pertanian Bogor, Bogor.