Effectiveness of Weed Solut-Ion as herbicide adjuvant to control weeds in oil palm plantations

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Abstract. The use of herbicides is an effective and efficient way to control weeds in oil palm plantations. However, overdoses application of herbicides is hazardous to the environment. Therefore, it is necessary to find a method to reduce hazardous effects caused by excessive doses of herbicides. Adjuvant herbicides are a well-known compound that could enhance herbicide performance. Weed Solut-ion (WS) contains 2-sodium amine allegedly reduces herbicide dosage at the same time enhances its performance. The objective of this research was to determine the response application of Weed Solution as herbicide adjuvant for paraquat and fluroxypyr by reducing the dosage so that the application can be more efficient and environmentally friendly. The experiment was conducted in the Socfin Group Plantation using a completely block design with two treatments (control; paraquat:WS = 50:50; fluroxypyr:WS = 50:50). The results showed that weeds control and regrowth rate from the treatment (paraquat:WS = 50:50) were not significantly different from the control. The cost efficiency resulted from the treatment was 25.56%. The dose treatment of fluroxypyr combined with WS (doses 50:50) was not significantly different from control, and the cost efficiency was 36.43%.

1. Introduction

Weed is the one of a major problem in oil palm plantation because it will lead to a nutrient deficiency in oil palm tree that can cause yield loss [1]. Most of the weed control is using chemical or known as herbicides because of its effectiveness, less time consuming, and low cost compared with using mechanical control. Paraquat, fluroxypyr, metsulfuron, ammonium gluphosinate, and glyphosate are commonly used by planters to control weeds [2].

According to Aktar et al. [3], there are a lot of problems found because of the use of herbicides in uncontrolled doses which can lead to the damaging environment (contamination, kill non-target species etc.), weed resistance, and human health. Uncontrolled doses application happens because some cases showed that normal doses did not control weed so that planters using higher doses to get more effective in controlling weeds. This could lead to resistance and a higher amount of contamination in the environment.

Controlling the use and the doses of herbicides are needed to reduce their negative effect. Adjuvant herbicides are known as a compound that could enhance herbicides performances although the doses of herbicides decreased. Weed Solut-ion (WS) contains 2-sodium amine is alleged could reduce doses
but enhance the performance of herbicides. The objective of this research was to know the response application of Weed Solution as herbicide adjuvant for paraquat and fluroxypyr by reducing the doses so that the application can be more efficient and environmentally friendly.

2. Materials and Methods

2.1. Place and Date

The experiment was conducted juvenile oil palm plantations: Matapao plantation Block 40 (date of planted in 2014; fluroxypyr’s treatment) and Bangun Bandar plantation block 90 (date of planted 2014; fluroxypyr’s treatment); block 31 (date of planted 2014; paraquat’s treatment) from July to October 2015.

2.2. Treatment and Application

The area of the experiment was identified before application to know the population of weeds. The treatment of this experiment was using two active ingredients of herbicides i.e paraquat, fluroxypyr, and glyphosate. The dosage that used as a described in Table 1 and 2. Each of the treatments was mixed well before applied. The mixture was sprayed to all over the weed’s surface until completely wet.

| Treatments | Paraquat (mL/Ha) | (WS) | Metsulfuron-methyl (g/ha) |
|------------|----------------|------|--------------------------|
| P1 (Control) | Paraquat | 200  | - | 10 |
| P2 | Paraquat + WS | 100 | 100 | 10 |
| P3 | Paraquat + WS | 100 | 100 | 5 |

| Treatments | Fluroxypyr (mL/Ha) | WS (mL/Ha) |
|------------|----------------|-----------|
| F1 (control) | Fluroxypyr | 40 | - |
| F2 | Fluroxypyr + WS | 20 | 20 |

| Treatment | Glyphosate (mL/Ha) | 2,4-D (mL/Ha) | WS (mL/Ha) |
|-----------|----------------|-------------|-----------|
| G1 (control) | 300 | - | - |
| G2 | 150 | - | - |
| G3 | 300 | 100 | - |
| G4 | 150 | 50 | - |
| G5 | 350 | - | - |
| G6 | 175 | - | 175 |

2.3. Experimental design and observation

The experimental design was using a randomized complete block design with three replicates for each treatment. The layout of each treatment unit within a group is determined in such a way so that the target weed distributions are evenly the same. Post spraying assessments were carried out at weekly intervals on percentage weed killed and percentage weed regeneration (until 2 months). Variable of observation consisted of the efficacy of each treatment and cost efficiency. The effectivity of herbicides combined with Weed Solut-ion was compared with utilized doses (full doses, without WS). Analysis of variance was conducted and means were compared by Duncan’s Multiple Range Test and Tukey at 5% level of significance.
3. Results and Discussion

3.1. The effectiveness of 2-Sodium Amine Combined with Fluroxypyr Treatment

The major weed population recorded in this experiment in Matapao and Kebun Bandar plantation was mainly *Mucuna bracteate*. This species supposed to be a land cover crop to enrich nutrient in the soil and decrease evaporation [4,5]. This species became a weed if uncontrolled because of its fast-growing and cover the immature oil palm tree quickly. Table 4 and Figure 1 showed successful weed control was achieved at 4 weeks after application.

Table 4. The effectiveness of fluroxypyr (F1, control) and the combination of fluroxypyr+WS (F2) at Matapao plantation.

| Treatments                        | Replicates | Weed control (%) |
|-----------------------------------|------------|-----------------|
| Fluroxypyr 40 mL/Ha               |            |                 |
| F1 U1                             | 100 a      |                 |
| F1 U2                             | 100 a      |                 |
| F1 U3                             | 100 a      |                 |
| Fluroxypyr 20 mL/Ha+ 20 mL/Ha     |            |                 |
| F2 U1                             | 100 a      |                 |
| F2 U2                             | 100 a      |                 |
| F2 U3                             | 100 a      |                 |

Figure 1. Effectiveness treatment of fluroxypyr combined with Weed Solut-ion (WS) at Matapao plantation. (A) control (F1) utilized doses before treatment; (B) F2 before treatment; (C) F1 at 4 weeks after application; (D) F2, combination of fluroxypyr and WS at 4 weeks after application.

Table 4 and Figure 2 showed the successful effectiveness of fluroxypyr combined with WS compared with control at Kebun Bandar plantation. This result showed there is no significant difference between an application using normal or utilized doses of fluroxypyr and half doses of fluroxypyr combined with WS. All of *M. bracteata* were dried at 4 weeks after application. Fluroxypyr had systemic effects so that have successfully controlled the weeds started 2 weeks after treatment and completely dried at 1 month after treatment. *Mucuna bracteata* regeneration in both of treatment was faster than other weeds. They had regrowth at 4 weeks after treatment. According to Harahap *et al.* growth rate of *Mucuna bracteata* at the beginning of planting was 2-3 m² per month.
Table 5. The effectiveness of fluroxypyr (F1, control) and the combination of fluroxypyr+WS (F2) at Kebun Bandar plantation.

| Treatments                         | Replicates | Weed control (%) |
|-----------------------------------|------------|-----------------|
| Fluroxypyr 40 mL/Ha               |            |                 |
| F1                                | U1         | 100 a           |
|                                  | U2         | 100 a           |
|                                  | U3         | 100 a           |
| Fluroxypyr 20 mL/Ha + 20 mL/Ha    |            |                 |
| F2                                | U1         | 100 a           |
|                                  | U2         | 100 a           |
|                                  | U3         | 100 a           |

Figure 2. Effectiveness treatment of fluroxypyr combined with Weed Solution (WS) at Kebun Bandar plantation. (A) control (F1) utilized doses before treatment; (B) F2 before treatment; (C) F1 at 4 weeks after application; (D) F2, a combination of fluroxypyr and WS at 4 weeks after application.

Combination of fluroxypyr and Weed Solution (WS) could kill weed although used a half dose of fluroxypyr. The active compound of WS enhances the performance of fluroxypyr to control *M. bracteata*. This adjuvant was allegedly acted as a surfactant to make penetration of fluroxypyr easier. *Mucuna bracteata* regeneration in both of treatment was faster than other weeds. They had regrowth at 4 weeks after treatment [6]. According to Harahap *et al.*[3] growth rate of *M. bracteata* at the beginning of planting was 2-3 m² per month [7].

3.2 Effectiveness of Weed Solution Combined with Paraquat and Metsulfuron-methyl

Target weed in this experiment was *Stenochlaena palustris*. The result showed that percentage of weed control between normal doses (P1) and the combination of paraquat, metsulfuron-methyl, and Weed Solution (WS) was not significantly different at 2 and 3 months after treatment (MAT) (Table 6). P2 treatment had the lowest percentage of dried weed than others, but the result was not significantly different. The result indicated that decreasing the recommended doses of herbicides (paraquat and metsulfuron-methyl) until 50% and combined with Weed solution still effective to control *S.*
Regrowth rate of *S. palustris* at 3 months after the application was not significant differences between all treatments (Figure 3). P2 treatment showed a higher regrowth rate among other but not significant different with control (P1) and P3. This might be because the percentage of decrease population weed in this treatment was lower so that part of *S. palustris* had growth faster. According to Faiz [8], paraquat was more effective herbicides than glyphosate and ammonium glufosinate, but the chemical is not suitable for sustainability in oil palm. So that reducing the doses of paraquat could help planters to decrease the side effect of paraquat on the environment. The addition of Weed Solut-ion can reduce paraquat residue on oil palm weeding circle soil [9].

**Table 6.** The effectiveness of paraquat and combination of paraquat + methyl metsulfuron + WS at Matapao plantation.

| Treatments | Paraquat (mL/Ha) | Metsulfuron-methyl (gr/Ha) | WS (mL/Ha) | Weed control (%) |
|------------|------------------|-----------------------------|------------|------------------|
| P1         | 200              | 10                          | -          | 99.20 ± 2.65 a¹ | 98.00 ± 1.06a |
| P2         | 100              | 10                          | 100        | 91.67 ± 7.94 a   | 90.60 ± 6.24a |
| P3         | 100              | 5                           | 100        | 98.67 ± 0.23 a   | 97.87 ± 0.57a |

¹Means followed by the same letter are not significantly differed at 5% level using DMRT.

**Figure 3.** Effectiveness treatment of paraquat combined with Weed Solut-ion (WS) at Matapao plantation. (A) control (P1) utilized doses before treatment; (B) P2 before treatment; (C) P3 before treatment; (D) P1 at 2 months after treatment (MAT); (E) P2 at 2 MAT; (F) P3 at 2 MAT; (G) P1 at 3 MAT; (H) P2 at 3 MAT; (I) P3 at 3 MAT.
3.3 Effectiveness of Weed Solution Combined with Glyphosate and 2,4 D

Analysis of weed population in block 36 Matapao plantation before the application was dominated by weeds as shown in Table 7 and Figure 4. Almost 75% of vegetation was dominated by *Ottochloa nodosa* (Figure 4).

| Weeds                      | Weed population (%) |
|----------------------------|---------------------|
| *Ottochloa nodosa*         | 75                  |
| *Cynodon dactylon*         | 10                  |
| *Axonopus compressus*      | 5                   |
| *Ageratum conyzoides*      | 3                   |
| *Synedrella nudiflora*     | 2                   |
| others                     | 5                   |

Table 7. Analysis vegetation of weed in block 36 Matapao plantation.

![A](image1.jpg) ![B](image2.jpg) ![C](image3.jpg) ![D](image4.jpg) ![E](image5.jpg)

Figure 4. Vegetation of weeds in block 36 Matapao plantation. (A) *Ottochloa nodosa*; (B) *Cynodon dactylon*; (C) *Ageratum conyzoides*; (D) *Axonopus compressus*; and (E) *Synedrella nudiflora*.

Table 8. The effectiveness of glyphosate, 2,4 D, and combination with Weed Solution (WS)

| Treatments | Glyphosate (mL/Ha) | 2,4 D (mL/Ha) | WS (mL/Ha) | % Weed control | % Weed regrowth |
|------------|--------------------|---------------|------------|----------------|----------------|
| G1         | 300                | -             | -          | 100.00 a       | 4.00 ab         |
| G2         | 150                | -             | 150        | 99.27 ab       | 4.33 ab         |
| G3         | 300                | 100           | -          | 99.87 a        | 4.00 ab         |
| G4         | 150                | 50            | 200        | 99.00 ab       | 6.60 a          |
| G5         | 350                | -             | -          | 99.87 a        | 2.80 b          |
| G6         | 175                | -             | 175        | 98.33 b        | 5.18 ab         |

<sup>a</sup> Means followed by the same letter are not significantly different at 5% level using DMRT

The result showed that treatment all treatment was not significantly different than control (Table 8 and Figure 5). These indicated that decreasing the recommended doses of herbicides and combined with Weed Solution still effective to control weeds. Glyphosate had systemic effects so that have successfully controlled the weeds starting 3 weeks after treatment and completely dried at 1 month.
after treatment. The weeds initially became yellowish at 2 weeks after treatment and turned brown or dried then finally dried up at 1 month after treatment. The regrowth rate of weeds started at 2 months after treatment, all treatment was not significantly different with control in growth rate (Figure 6).

Figure 5. The effectiveness of glyphosate, 2,4 D, and combination using Weed Solution (WS) at 1 month after treatment. (A) G1, 300 mL/Ha glyphosate; (B) G2, 150 mL/Ha glyphosate + 150 mL/Ha WS; (C) G3, 300 mL/Ha glyphosate + 100 mL/Ha 2,4 D; (D) G4, 150 mL/Ha glyphosate + 50 mL/Ha 2,4 D + 200 mL/Ha WS; (E) G5, 350 mL/Ha glyphosate; (F) G6, 175 mL/Ha glyphosate + 175 mL/Ha W.

Figure 6. Regrowth of glyphosate, 2,4 D, and combination using Weed Solution (WS) at 2 months after treatment. (A) G1, 300 mL/Ha glyphosate; (B) G2, 150 mL/Ha glyphosate + 150 mL/Ha WS; (C) G3, 300 mL/Ha glyphosate + 100 mL/Ha 2,4 D; (D) G4, 150 mL/Ha glyphosate + 50 mL/Ha 2,4 D + 200 mL/Ha WS; (E) G5, 350 mL/Ha glyphosate; (F) G6, 175 mL/Ha glyphosate + 175 mL/Ha WS.

3.4 Cost Efficiency
Cost comparison showed recommendation dosages of herbicides to be more expensive than combination herbicides with Weed Solution (WS) (the price of herbicides and Weed Solution was...
followed the price list in Socfin group plantation in 2015). The cost/Ha of fluroxypyr was IDR 6,275 and cost/Ha of combination Fluroxypyr and WS was IDR 3,897, so the difference was about IDR 2,378. In one year, plantation could save up to IDR 28,536/Ha/year and the cost efficiency was up to 37.90%. The cost/Ha of paraquat and metsulfuron-methyl (P1) was IDR 14,112, for P3 cost/Ha, was IDR 10,856 and the cost gap was about IDR 3,265. In one year, plantation did twice rotation and cost efficiency for 35,000 Ha was up to 23.07%. cost/Ha of glyphosate and 2,4 D was about IDR 15,721, and its combination with WS was about IDR 13,561 so that the efficiency was about 13.74%.

4. Conclusions

Application of 20 mL/Ha fluroxypyr and 20 mL/ha Weed Solut-ion (WS) was efficient to control weed in immature oil palm tree. Doses treatment used paraquat 100 mL/Ha, 5 g/Ha, and 100 mL/Ha WS had the same effectiveness with utilized doses. Combination of 150 mL/Ha glyphosate and 150 mL/Ha WS could control weed growth. Therefore, it is more economical to use a combination of Weed Solut-ion and a half doses of herbicides.

5. References

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