The efficacy indaziflam on weed seedbank vertically on the ultisol soil on palm oil plantations

P K Tampubolon, E Purba* and Mukhlis

Agrotechnology Study Program, Faculty of Agriculture, Universitas Sumatera Utara, Medan, Indonesia-20155

E-mail: *epurba@yahoo.com

Abstract. Seedbank control is important in integrated weed management. This study aims to determine the dose of indaziflam to seedbank at some depth of soil on oil palm plantations. The experiment used factorial randomized block design with four replications. Measured at an indaziflam dose 75, 100, 150 and 200 gram of active ingredients per hectare (g.a.i.ha⁻¹), and soil depth 0-5, 5-10, 10-15 and 15-20 cm. Results showed that indaziflam doses 150-200 g.a.i.ha⁻¹ were able to suppress the presence Eleusine indica at 4.8 and 12 weeks after application (WAA) (71.91-91.13%). Dosage 75-200 g.a.i.ha⁻¹ effective controlling Cynodon dactylon at 8 and 12 WAA (66.07-89.29%). Dosage 150-200 g.a.i.ha⁻¹ effective controlling Kyllinga nemoralis at 4 and 12 WAA (76.57-100%). Dosage 100-200 g.a.i.ha⁻¹ effective controlling Phyllanthus niruri (100%), dosage 150-200 g.a.i.ha⁻¹ effective controlling Cleome rutidospermae (74.49-85.92%), and dosage 75-200 g.a.i.ha⁻¹ effective controlling Ageratum conyzoides (100%) at 12 WAA. Effectiveness indaziflam can suppress the presence Eleusine indica and Kyllinga nemoralis at a soil depth 0-20cm (4.8 and 12 WAA), Cynodon dactylon at a depth 5-20cm (8 and 12 WAA), and Ageratum conyzoides at a depth 0-15cm (12 WAA).

1. Introduction
Weed seedbank is the main source of weeds on agricultural land that can survive in the soil for many years. Weed seeds are spread horizontally and vertically inside the soil profile [1]. Immersion depth of weed seeds also affects the rate of germination. Immersion depth gives a different amount of germination [2]. Therefore, knowledge of the return of weed seedbank and the weed seedbank dynamics are important in the management of weeds for the future [1].

Weed control with pre-grown herbicides is important in integrated weed control strategies. Indaziflam ingredient active is one of the herbicides which pre-emergence inhibit cellulose biosynthesis which is applied before weed seeds germinate or just appear on the ground to anticipate resistance and weed succession [3]. Pre-grown herbicides can remain active in the soil for a period of time so that the soil will be relatively free of weeds over a period of time. The effectiveness of herbicides in the soil can be differently influenced by differences in the characteristics of the soil [4].

Oil palm plantations are inseparable from the use of herbicides in controlling weeds chemically, especially in the palm oil disk region. The type of soil for oil palm plantations, ultisol soils, can affect the differences in the types of weeds that grow and how to control them, one of which is to influence the efficacy of herbicides applied to weeds. The depth of weed seeds in the soil also affects the rate of germination and the way it is controlled. The use of indaziflam pre-grown herbicides on palm oil
plates on ultisol soil is expected to be able to suppress the growth of seedbank weeds in the soil vertically, however, the depth of seedbank which can be affected by indaziflam has never been reported on ultisol soil.

2. Materials and Methods

This research was conducted in a plastic house at the Faculty of Agriculture, Universitas Sumatera Utara, at the weed research centre, Faculty of Agriculture, Universitas Sumatera Utara and in the field/oil palm plantations have not produced Afdeling 4 Kebun Rambutan Perkebunan Nusantara III (Persero) Serdang Bedagai. This study was conducted in January 2018 until July 2018.

The material used in this study consisted of growing media in the form of top soil of ultisol soil, sterile soil, soil seedbank, indaziflam herbicide (Becano 500 SC), and water.

This experiment used a factorial randomized block design with 4 replications. The data were analysed by ANOVA, then proceed to the Duncan's Multiple Range Test (DMRT) test at 5% level with IBM SPSS Statistics 20 software.

The research was carried out in immature oil palm plantations using a plot of 5 oil palm plant plates for each plot and the plot is eroded using a hoe. Immediately after the erosion of the soil surface is taken the seedbank soil in each treatment plot which is carried out using a soil core tool with a diameter of 5cm. Soil samples were taken as deep as 20 cm at 10 points per plot per replicate that were placed zigzagging with the intention of representing all plot areas. The soil in the 20 cm soil core is divided into four parts, each 5 cm long, that is 0-5, 5-10, 10-15 and 15-20 cm, for further sprout testing. Immediately after soil seedbank extraction, indaziflam was sprayed using a knapsack sprayer at doses of 75, 100, 150, and 200 g a.i. ha\(^{-1}\) by first calibrating to determine the spray volume.

At 4, 8 and 12 the WAA was taken again to take the seedbank land on each treatment plot. Soil seedbank from different depths taken from the field at 0, 4, 8 and 12 WAA was germinated in pots with sterile soil on the weed research centre of the Faculty of Agriculture, Universitas Sumatera Utara. Then identified and counted the number of each species that grows regularly until there are no more new plants appear until 8 weeks after being grown in pots.

3. Results and Discussion

3.1 Results

Percentage of effectiveness indaziflam on soil seedbank control after application indaziflam at several doses 0, 4, 8 and 12 WAA after growing in pots using sterile soil for 8 weeks can be seen in Figure 1.

Obtained that percentage of effectiveness indaziflam with a dose 75-200 g a.i.ha\(^{-1}\) at 0 WAA in controlling Eleusine indica seedbank ranging from 3.31-34.25%; Cleome rutidospermae 4.01-74.82%; Cynodon dactilon 4.00-91.33%; Phylanthus niruri 80.65-100%; Cyperus rotundus 19-69%; Kyllinga nemoralis 27.88-51.41%; and Ageratum conyzoides ranged from 24.24-60.61%.

It was obtained that the percentage of effectiveness indaziflam herbicide at a dose 75-200 g ai ha\(^{-1}\) at 4 WAA in controlling the Eleusine indica seedbank ranging from 79.12-87.11%; Cleome rutidospermae 7.35-80.88%; Cynodon dactilon 68.42-100%; Phylanthus niruri 100%; Cyperus rotundus 79.00-98.00%; and Kyllinga nemoralis ranged from 2.76-76.57%.

It was found that the percentage of the effectiveness indaziflam herbicide at a dose 75-200 g ai ha\(^{-1}\) at 8 WAA in controlling the Eleusine indica seedbank ranged from 79.12-87.11%; Cleome rutidospermae 3.85-88.46%; Cynodon dactilon 33.93-89.29%; Phylanthus niruri 5-100%; Cyperus rotundus 3.08-100%; Kyllinga nemoralis 0-70.13%; and Ageratum conyzoides ranged from 16.67-100%.

It was found that the percentage of the effectiveness indaziflam herbicide at a dose 75-200 g ai ha\(^{-1}\) at 12 WAA in controlling the Eleusine indica seedbank ranged from 0.39-91.13%; Cleome rutidospermae 0.41-85.92%; Cynodon dactilon 40.20-76.89%; Phylanthus niruri 1.43-100%; Cyperus rotundus 7.50-85.00%; Kyllinga nemoralis 2.82-100%; and Ageratum conyzoides at 100%.
Figure 1. Percentage of indaziflam effective to seedbank controlling in soil and observed at 0 (a), 4 (b), 8 (c), and 12 WAA (d).

The number of seedbank of weed species that grow after application of indaziflam at several doses at 0, 4, 8 and 12 WAA after being grown in pots using sterile soil for 8 weeks can be seen in Table 1.
Table 1. A number of seedlings emerge from soil seedbanks treated at various rates of indaziflam and observed at 0, 4, 8, and 12 WAA.

| Doses  | Species                  | Eleusine indica | Cleome rutidospermae | Cynodon dactilon | Phyllanthus niruri | Cyperus rotundus | Kyllinga nemoralis | Ageratum conyzoides |
|--------|--------------------------|-----------------|----------------------|------------------|------------------|-----------------|------------------|---------------------|
| g a.i. |             |                 |                      |                  |                  |                 |                  |                     |
| ha⁻¹   |             |                 |                      |                  |                  |                 |                  |                     |
|        | 0 WAA       |                 |                      |                  |                  |                 |                  |                     |
| 0      | 922.29      | 1396.18 b       | 764.33 b             | 157.96           | 509.55           | 4331.21 b       | 168.15           |                     |
| 75     | 891.72      | 575.80 a        | 188.54 ab            | 30.57            | 412.74           | 2104.46 a       | 66.24            |                     |
| 100    | 703.18      | 448.41 a        | 66.24 a              | 0.00             | 157.96           | 2517.20 ab      | 96.82            |                     |
| 150    | 606.37      | 351.59 a        | 96.82 a              | 0.00             | 321.02           | 3123.57 ab      | 66.24            |                     |
| 200    | 606.37      | 1340.13 b       | 733.76 b             | 0.00             | 285.35           | 3123.57 ab      | 127.39           |                     |
|        | 4 WAA       |                 |                      |                  |                  |                 |                  |                     |
| 0      | 1977.07 b   | 346.50          | 96.82                | 30.57            | 1528.66 b        | 2588.53 b       | 0.00             |                     |
| 75     | 382.17 a    | 321.02          | 30.57                | 0.00             | 321.02 ab        | 1783.44 ab      | 0.00             |                     |
| 100    | 412.74 a    | 285.35          | 30.57                | 0.00             | 96.82 a          | 1717.20 ab      | 0.00             |                     |
| 150    | 254.78 a    | 66.24           | 0.00                 | 0.00             | 224.20 ab        | 2517.20 b       | 0.00             |                     |
| 200    | 351.59 a    | 66.24           | 0.00                 | 0.00             | 30.57 a          | 606.37 a        | 0.00             |                     |
|        | 8 WAA       |                 |                      |                  |                  |                 |                  |                     |
| 0      | 1814.01 b   | 264.97          | 285.35 b             | 203.82           | 331.21           | 1177.07         | 152.87           |                     |
| 75     | 891.72 ab   | 66.24           | 188.54 ab            | 193.63           | 96.82            | 830.57          | 127.39           |                     |
| 100    | 1243.31 ab  | 254.78          | 96.82 a              | 0.00             | 321.02           | 1177.07         | 0.00             |                     |
| 150    | 509.55 a    | 30.57           | 30.57 a              | 0.00             | 0.00             | 825.48          | 0.00             |                     |
| 200    | 224.20 a    | 224.2           | 30.57 a              | 0.00             | 127.39           | 351.59          | 0.00             |                     |
|        | 12 WAA      |                 |                      |                  |                  |                 |                  |                     |
| 0      | 3964.33 c   | 2496.82 b       | 2491.72 b            | 351.59 b         | 203.82           | 361.78 b        | 224.20 b         |                     |
| 75     | 2323.57 b   | 575.80 a        | 575.80 a             | 351.59 b         | 188.54           | 96.82 ab         | 0.00 a           |                     |
| 100    | 3949.04 c   | 2486.62 b       | 2486.62 b            | 0.00 a           | 30.57            | 351.59 b        | 0.00 a           |                     |
| 150    | 733.76 a    | 636.94 a        | 1212.74 ab           | 0.00 a           | 96.82            | 0.00 a          | 0.00 a           |                     |
| 200    | 351.59 a    | 351.59 a        | 1115.92 ab           | 0.00 a           | 66.24            | 0.00 a          | 0.00 a           |                     |

It was found that various doses indaziflam herbicide at 0 WAA were significantly able to suppress weed growth *Cleome rutidospermae*, *Cynodon dactilon* and *Kyllinga nemoralis* compared to other species. Indaziflam doses 75-150 g ai ha⁻¹ able to inhibit the presence *Cleome rutidospermae* 351.59-575.80 seedbank. An effective dose in inhibiting *Cleome rutidospermae* found at 150 g ai ha⁻¹ (74.82%). The dose 100-150 g ai ha⁻¹ can inhibit the presence *Cynodon dactilon* 66.24 and 96.82 seedbank. An effective dose in inhibiting *Cynodon dactilon* found in 100 g ai ha⁻¹ (91.33%). While the effective dose in inhibiting *Kyllinga nemoralis* is 75 g ai ha⁻¹ of 2104.46 seedbank (51.41%).

It was found that various doses indaziflam in 4 WAA were actually able to suppress the growth of weeds *Eleusine indica*, *Cyperus rotundus*, and *Kyllinga nemoralis* compared to other species. The dose 75-200 g ai ha⁻¹ can inhibit the presence of *Eleusine indica* ranging from 254.78- 412.74 seedbank. The effective dose in inhibiting *Eleusine indica* is 150 g ai ha⁻¹ (87.11%). The dosages of indaziflam 100 and 200 g ai ha⁻¹ were able to inhibit the presence of *Cyperus rotundus* by 96.82 and 30.57 seedbank. An effective dose in inhibiting *Cyperus rotundus* is found at 200 g ai ha⁻¹ (98%). While the effective dose in inhibiting *Kyllinga nemoralis* is in 200 g ai ha⁻¹ of 606.37 seedbank (76.57%).
It was found that various doses of indaziflam in 8 WAA were significantly able to suppress the growth of weeds *Eleusine indica* and *Cynodon dactilon* compared to other species. The dosages of indaziflam 150 and 200 g a.i.ha\(^{-1}\) can inhibit the presence of *Eleusine indica* by 509.55 and 224.2 seedbank. The effective dose in inhibiting *Eleusine indica* is 200 g a.i.ha\(^{-1}\) (87.64\%). The dose of indaziflam 100-200 g a.i.ha\(^{-1}\) can inhibit the presence of *Cynodon dactilon* by 96.82; and 30.57 seedbank. The effective dose in inhibiting *Cynodon dactilon* is 150 g a.i.ha\(^{-1}\) (89.29\%).

Provided that the various doses indaziflam on 12 WAA significantly suppressed the growth of weeds *Eleusine indica*, *Cleome rutidospermae*, *Cynodon dactilon*, *Phyllanthus niruri*, *Kyllinga nemoralis* and *Ageratum conyzoides*. The dosages indaziflam 150 and 200 g a.i.ha\(^{-1}\) effectively inhibited the presence of *Eleusine indica* at 733.76 and 351.59 seedbank. The effective dose in inhibiting *Eleusine indica* is 200 g a.i.ha\(^{-1}\) (91.13\%). A dose of indaziflam 75, 150 and 200 g a.i.ha\(^{-1}\) effectively inhibit the presence of *Cleome rutidospermae* is 575.80; 636.94; and 351.59 seedbank. An effective dose in inhibiting *Cleome rutidospermae* is found at 200 g a.i.ha\(^{-1}\) (85.92\%). A dose of indaziflam 75 g a.i.ha\(^{-1}\) effectively suppresses the presence of *Cynodon dactilon* by 757.80 (76.89\%). The dosage of 100-200 g a.i.ha\(^{-1}\) indaziflam can inhibit the presence of *Phyllanthus niruri* by 0.00 seedbank. An effective dose in inhibiting *Phyllanthus niruri* is found at 100 g a.i.ha\(^{-1}\) (100\%). The dosage of indaziflam 150-200 g a.i.ha\(^{-1}\) effectively inhibits the presence of *Kyllinga nemoralis*, each of which is 0.00 seedbank. An effective dose in inhibiting *Kyllinga nemoralis* is 150 g a.i.ha\(^{-1}\) (100\%). The dose of indaziflam 75-200 g a.i.ha\(^{-1}\) can inhibit the presence of *Ageratum conyzoides* of 0.00 seedbank. An effective dose in inhibiting *Ageratum conyzoides* is 75 g a.i.ha\(^{-1}\) (100\%).

Seedbank weed species that grow after application indaziflam at some soil depth at 0, 4, 8 and 12 WAA after growing in pots using sterile soil for 8 weeks can be seen in Figure 2. It was found that indaziflam at 0 WAA was actually able to suppress the growth of weeds *Eleusine indica*, *Cleome rutidospermae*, and *Cyperus rotundus* at certain depths of soil. The effectiveness of Indaziflam in suppressing the growth of *Eleusine indica*, *Cleome rutidospermae*, and *Cyperus rotundus* is found at a depth of 15-20 cm, each of which is 76.43; 229.30; and 50.96 seedbank.

It was found that indaziflam at 4 WAA was actually able to suppress the growth of weeds *Eleusine indica* and *Kyllinga nemoralis* at certain depths of soil compared to other species. The effectiveness of indaziflam in suppressing the growth *Eleusine indica* found in 15-20 cm soil depth 76.43 seedbank. The species *Kyllinga nemoralis*, the effectiveness indaziflam in 0-5 cm depth 535.03 seedbank.

It was found that indaziflam in 8 WAA was actually able to suppress the growth of weeds *Eleusine indica*, *Cleome rutidospermae*, *Cynodon dactilon* and *Kyllinga nemoralis* in certain soil depths. The effectiveness of Indaziflam in suppressing the growth of *Eleusine indica* in the soil depth 0-10 cm and 15-20 cm, respectively 407.64; 764.33; and 738.85 seedbank. Indaziflam effectiveness in suppressing the growth of *Cleome rutidospermae* contained in the 5-20 cm soil depth respectively 101.91; 25.48; and 101.91 seedbank. Species *Cynodon dactilion*, the effectiveness of indaziflam at 5-10 cm soil depth 50.96 seedbank. The effectiveness of indaziflam in suppressing the growth of *Kyllinga nemoralis* found in soil depths 10-20 cm each of 280.25 and 76.43 seedbank.

It was found that indaziflam in 12 WAA was actually able to suppress the growth of weeds *Eleusine indica*, *Cynodon dactilon*, *Kyllinga nemoralis*, and *Ageratum conyzoides* in certain soil depths. The effectiveness indaziflam in suppressing the growth of *Eleusine indica* found in soil depths 0-10 and 15-20 cm, respectively 458.60; 993.63; and 1961.78 seedbank. The effectiveness of indaziflam in suppressing the growth *Cynodon dactilon* found in soil depths 10-20 cm, respectively 611.46 and 127.39 seedbank. The effectiveness of indaziflam in suppressing the growth of *Kyllinga nemoralis* found at a soil depth 5-20 cm, each of which is 25.48 and 0.00 seedbank. Effectiveness indaziflam in suppressing the growth of *Ageratum conyzoides* found in 0-15 cm soil depth 0.00 seedbank.
Table 1. Number of seedlings emerging from soil seedbank treated at various rates of soil depth

| Time of application | Ei (Eleusine indica) | Cr (Cleome rutidospermae) | Cd (Cynodon dactilon) | Pn (Phyllanthus niruri) | Crt (Cyperus rotundus) | Kn (Kyllinga nemoralis) | Ac (Ageratum conyzoides) |
|---------------------|---------------------|----------------------------|-----------------------|------------------------|------------------------|------------------------|-------------------------|
| 0 WAA               | 0                   | 0                          | 0                     | 0                      | 0                      | 0                      | 0                       |
| 4 WAA               | 0                   | 0                          | 0                     | 0                      | 0                      | 0                      | 0                       |
| 8 WAA               | 0                   | 0                          | 0                     | 0                      | 0                      | 0                      | 0                       |
| 12 WAA              | 0                   | 0                          | 0                     | 0                      | 0                      | 0                      | 0                       |

**Figure 2.** A number of seedlings emerge from soil seedbank treated at various rates of soil depth.

3.2 Discussion

In general, the results of this study indicate that indaziflam herbicides with certain doses can suppress the presence of weeds *Eleusine indica* at 4, 8 and 12 WAA, able to suppress the presence of weeds *Cynodon dactilon* at 8 and 12 WAA, it was able to suppress the presence of *Kyllinga nemoralis* at 4 and 12 WAA and suppress the presence of *Cleome rutidospermae, Phyllanthus niruri,* and *Ageratum conyzoides* at 12 WAA. This is because the indaziflam herbicide can inhibit the hypocotyl growth of weed seeds *Eleusine indica* and can damage the growth of roots *Cynodon dactilon*. Both species of weeds include seasonal weeds. This is consistent with the literature [5] stating that indaziflam can inhibit cellulose biosynthesis production <1 hour of treatment. In addition, [6] also stated that indaziflam can reduce the amount of insoluble nitric acid in hypocotyl seedlings *Arabidopsis* 5-day-
old. [7] stated that the indaziflam herbicide was a broad-spectrum pre-grown herbicide controlling several seasonal weeds and broadleaf.

In general, the results of this study indicate that the effectiveness of indaziflam herbicide is able to suppress the presence of *Eleusine indica* and *Kyllinga nemoralis* weeds with certain soil depths at 4, 8, and 12 WAA. The effectiveness of indaziflam herbicide is also able to suppress the growth of *Cynodon dactilon* with certain soil depths at 8 and 12 WAA and *Ageratum conyzoides* at certain soil depths at 12 WAA. This is in accordance with the literature [8] stating that indaziflam herbicides have the potential to survive and be washed in groundwater. Indaziflam mobility is classified as low to moderate based on the absorption coefficient. [9] also stated that the coefficient of soil C-organic uptake ($K_{oc}$) of the indaziflam herbicide was $<1000 \text{ mL g}^{-1}$ where this coefficient was the binding strength of the herbicide in the soil.

In this study also obtained the application of indaziflam herbicides with various doses capable of suppressing the presence of *Cyperus rotundus* at only 4 WAA, this can be influenced by the period of seed dormancy where the seedbank germination process can be influenced by seed dormancy which can be caused by the absence of imbibition process (the entry of water into the seeds), respiration is hampered, movement of food reserves is inhibited, and the low metabolic rate that causes the seedbank not to germinate at certain observations.

4. Conclusions

Indaziflam herbicides with doses of 150-200 g a.i.ha$^{-1}$ can suppress the presence of weeds *Eleusine indica* at 4, 8, and 12 WAA. Indaziflam herbicide with a dose of 75-200 g a.i.ha$^{-1}$ effectively controls *Cynodon dactilon* at 8 and 12 WAA. Indaziflam herbicide with a dose of 150-200 g a.i.ha$^{-1}$ effectively controls *Kyllinga nemoralis* at 4 and 12 WAA while indaziflam with a dose of 100-200 g a.i.ha$^{-1}$ is effective in controlling *Phyllanthus niruri*, doses of 150-200 g a.i.ha$^{-1}$ are effective in controlling *Cleome rutidospermae* and a dose of 75-200 g a.i.ha$^{-1}$ is effective in controlling *Ageratum conyzoides* at 12 WAA. The effectiveness of indaziflam herbicide is able to suppress the presence of *Eleusine indica* and *Kyllinga nemoralis* weeds with a soil depth of 0-20 cm at 4, 8, and 12 WAA. The effectiveness of indaziflam herbicide can reduce the presence of weeds *Cynodon dactilon* with a soil depth of 5-20 cm at 8 and 12 WAA. The effectiveness of indaziflam herbicide is also able to suppress the growth of *Ageratum conyzoides* at a soil depth of 0-15 cm at 12 WAA.

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