Population dynamics of weeds in oil palm (*Elaeis guineensis* Jacq.) circle weeding area affected by herbicide application

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Abstract. Weed problems in oil palm field were mainly overcomed by herbicide application. The application certain herbicides may lead to rapid population dynamic of certain species due to their different response to herbicides. Some species may less susceptible to certain herbicide whereas other species more susceptible. The objective of this study was to determine the population dynamic of weed species in circle weeding of oil palm in Serdang Bedagai, North Sumatra. Six treatments using glyphosate singly and mixture compared with manual weeding were evaluated for weed control. The treatments were arranged in a randomized block design with four replicates. Each treatment consisted of four circle weedings. The results showed that glyphosate 720 g a.i/ha + indaziflam 50 g a.i/hareduced seedbank and regrowth of weeds. Up to 12 weeks after application glyphosate 720 g a.i/ha + indaziflam 50 g a.i/ha is 29.46% total weeds dry weight compared to manual weeding. The effect of herbicide application on changes on the weed composition and weed seedbank are affected by the characteristic of herbicides and weed response to herbicide application.

1. Introduction

One of the biggest challenges in increasing the potential for palm oil production in Indonesia is the management of weeds. Weeds are undesirable plants because they can compete with the crops. Weed growth can reduce the production of fresh fruit bunches (FFB) by 20% not onlydue to competition against nutrients, but also allelopathic substances that are toxic to plants.

Weeds compete with cultivated plants against limited resources such as water, nutrition, and light [1]. In addition, weed infestations also encourage disease problems, serve as host alternatives to destructive insects and diseases, slow down harvest operations, increase production costs, reduce the market value of crops and increase the risk of fires in annual crops, plantations and protected forests [1]. The quality and quantity of weed seeds in the seedbank is very important in the weeds cycle that reproduce through the seed itself [2] which is the source of the weed population in the future.

Knowledge of the weed seedbank composition in soil contributes to the predictive and historical understanding of the composition of a plant community. Understanding the mechanism of weed seed distribution is very important as an effort to weed management strategy. In this study will be revealed about the dynamics of weed populations in terms of the ability of weed seeds to grow to the soil surface, the pattern of distribution of weed seedbank, and the effect of herbicide use on weed seedbank.

2. Materials and methods

This study consisted of two units. First unit was to study the effect of herbicides on soil seedbank composition in the circle weedings and the second unit was to investigate the effect of indaziflam This research was conducted in the field at Adolina Estate PT. Perkebunan Nusantara IV from July to December 2016. Weed vegetation was recorded prior to herbicide application and four weeks after application on circle weeding. Observations were carried out using quadratic method. Data were analyzed descriptivelydescribing the existing conditions of the site of study. The treatments on circle weedings consisted of seven treatments (glyphosate 720 g ai/ha + 2,4 dimethyl ammonium 186.43 g ai/ha, glyphosate 720 g ai/ha + methyl metsulfuron 20 g ai/ha, glyphosate 720 g ai/ha + fluroxypir 40 g ai/ha , glyphosate 720 g ai/ha + indaziflam 50 g ai/ha, glyphosate 720 g ai/ha + diuron 800 g ai/ha, and glyphosate 720 g ai/ha + oxyfluorfen 240 g ai/ha and manual weeding without herbicide application for a comparison. All treatments were arranged in a randomized block design with 4 replicates. Each treatments consisted of four circle weedings.

Weed seedbank compositition in the circles was analized by germinating the seeds in the soil samples collected from the circles using soil core. Soil samples were collected both prior to and post herbicide application. Soil samples were divided into four depth categories (0to1, 1to3, 3to5 and 5to10cm). Seeds in the soil samples were germinated in polybags containing 20cm deth of sterilized soil. Soil from each depth category was distributed on the sterilized soil media and watered regularly in order to have seedbank germinating and emerging to be observed. Number of seedlings were recorded regularly every two days until no new seedling emerged.

The weed seed introduction test was carried out by taking a soil sample that has been applied with herbicide to a depth of 20 cm by 2 points per treatment to measure and observe weeds that grow at various depths (0 to1, 1 to3, 3 to5, 5 to10, 10 to20 cm). *Eleusine indica* weed seeds taken one week before introduction are planted in paralon pipes containing soil from different depths of 100 seeds per paralon. To obtain weed to free soil weeded sterilized pipe that already contains the soil from the experimental garden using sterilizer furnace with temperature 60to70 C for 30 minutes. bservation of germination done since one week after weed seed sowing. While on the seed germination test in the layer zone after herbicide application, it is done by taking soil samples from each treatment to measuring 20 cm x 20 x 5 cm. The soil samples were taken two points north of the tree at each treatment. Soil sampling after one month of herbicidal application at ground depth zones 0to1, 1to3, 3to5, 5to10 cm at each treatment. Furthermore, descriptive observation is done by evaluating some zone into the soil after herbicide application and its effect on the existence of weed seed inside the depth zone. The soil taken from the disk is mixed and stirred evenly into one sample per treatment. The stirred soil sample is fed into a growth box measuring 20 cm x 20 cm x 5 cm thick 2 cm above the sterile soil present in the box. We observed the number of seed weed seeds that appeared at twotoweek intervals.

3. Results and discussion

3.1. Analysis of weed vegetation

The summed dominance ratio (SDR) value of the vegetation analysis on the circle weeding of oil palm illustrates the degree of dominance and the distribution of weeds. Table 1 shows the SDR value at the time of herbicide application which *Asystasia gangetica* was the predominant weed species in the treatment plots of H0, H1, H2, H3, and H4 whereas the species in the treatment plots of H5 and H6 were predominated by *Cleome rutidosperma* species.

SDR values were recalculated at four weeks after application (WAA) to determine the changes in the weed species dominance level in each treatment. Table 2 shows that *A. gangetica* was the dominant weed in the circles sprayed withH1, H2, H3, and H4and H0 (glyphosate 540 g a.e./Ha + 215 g a.i/2,4-D; glyphosate 540 g a.e./Ha + methyl metsulfuron 20 g a.i/Ha; glyphosate 540 g a.e./Ha + fluroxypir 50 g a.i/Ha; glyphosate 540 g a.e./Ha + indaziflam 50 g ai/Ha) and on manual weeding.There was a shift in the dominance of weeds in the treatment of H5 and H6 which was originally predominated by *C. rutidosperm* changed to bepredominated by *A. gangetica*. This suggests that the application of glyphosate with various mixtures is not able to control *A. gangetica* growth. Application of glyphosate

herbicide mixed with diuron and oxyfluorfen able to control the growth of *C. rutidosperma*satisfactorily. While the result of vegetation analysis on manual weeding treatment did not show any change of weed dominance level.

Table 1. Weed dominance level at the time of herbicide application

Weed species	Summed Dominance Ratio†						
	H0	H1	H2	H3	H4	H5	H6
	.....%.....						
Asystasia gangetica	27.53 (1)	52.18 (1)	52.78 (1)	49.17 (1)	54.42 (1)	25.73 (2)	19.51 (3)
Eleusine indica	21.04 (3)	28.85 (2)	19.44 (3)	28.04 (2)	0.00 (4)	19.96 (3)	23.22 (2)
Cynodon dactylon	16.49 (4)	13.09 (3)	0.00 (4)	6.66 (4)	0.00 (4)	9.56 (5)	12.37 (4)
Cleome rutidosperma	13.25 (5)	0.00 (5)	0.00 (4)	0.00 (5)	34.61 (2)	32.28 (1)	34.82 (1)
Cyperus kyllingia	21.69 (2)	5.88 (4)	27.78 (2)	16.13 (3)	10.97 (3)	12.46 (4)	10.09 (5)
SDR	100.00	100.00	100.00	100.00	100.00	100.00	100.00

†Numbers in the brackets are the sequence of weed dominance value levels.

H0= control (manual weeding)
H1= glyphosate 540 g ae/Ha + 215 g a.i/Ha 2,4-D
H2= glyphosate 540 g ae/Ha + methyl metsulfuron 20g ai/Ha
H3= glyphosate 540 g ae/Ha + fluroxypir 50 g a.i/Ha
H4= glyphosate 540 g ae/Ha + indaziflam 50 g ai/Ha
H5= glyphosate 540 g ae/Ha + diuron 80 g ai/Ha
H6= glyphosate 540 g ae/Ha + oxyfluorfen 240g a.i/Ha

Table 2. Summed dominance ratio level of weed species at four weeks after application (WAA)

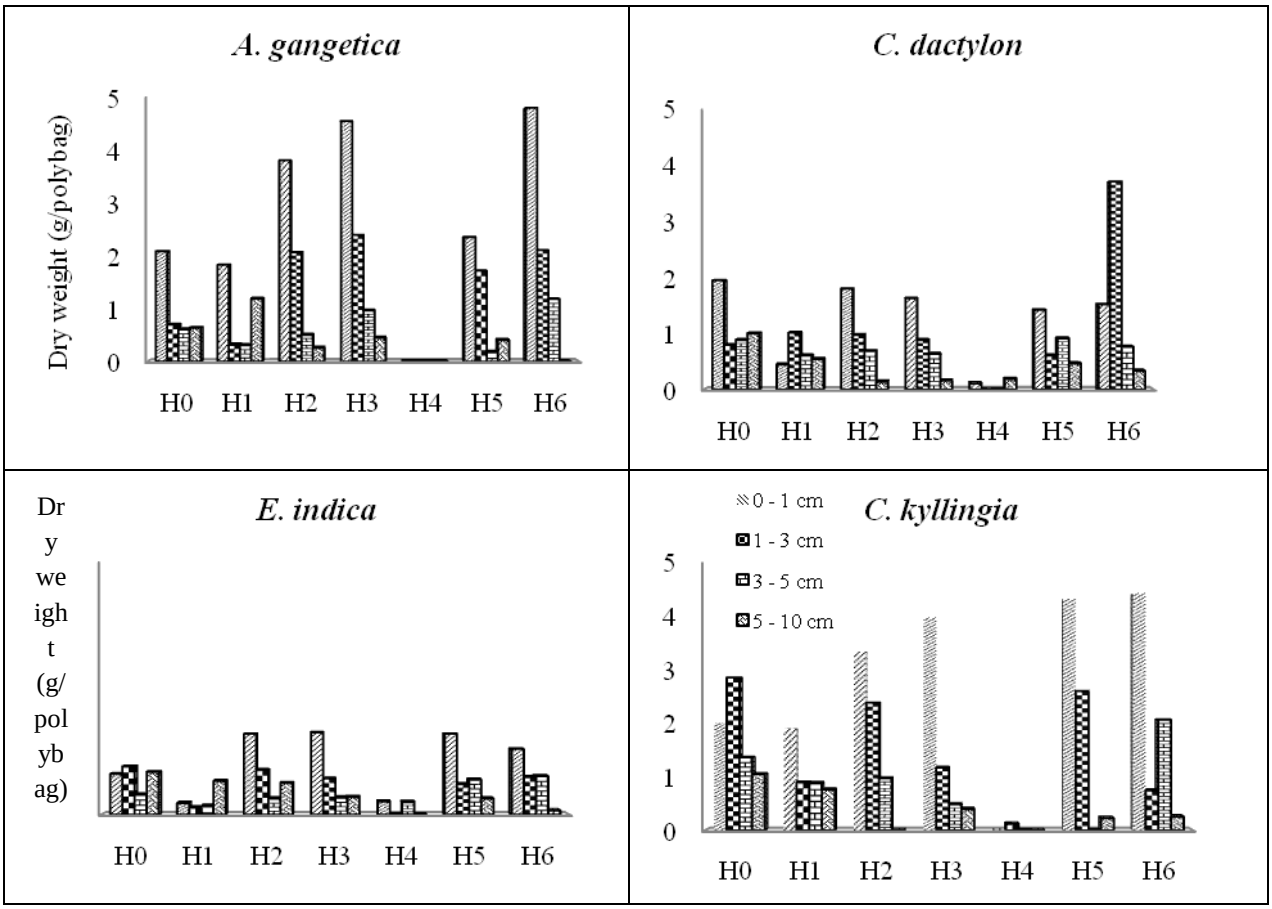
Weed species	Summed Dominance Ratio†						
	H0	H1	H2	H3	H4	H5	H6
	.....%.....						
Asystasia gangetica	27.01 (1)	39.90 (1)	41.71 (1)	41.87 (1)	21.76 (1)	42.66 (1)	36.77 (1)
Eleusine indica	19.72 (3)	24.27 (2)	18.92 (3)	25.67 (2)	12.94 (2)	20.10 (2)	21.72 (2)
Cynodon dactylon	18.68 (4)	6.46 (5)	11.53 (4)	5.30 (5)	0.00 (4)	15.26 (4)	18.98 (3)
Cleome rutidosperma	12.08 (5)	9.17 (4)	7.75 (5)	15.89 (3)	0.00 (4)	4.46 (5)	8.23 (5)
Cyperus sp	22.50 (2)	20.21 (3)	20.09 (2)	11.28 (4)	5.29 (3)	17.52 (3)	14.30 (4)
SDR	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The numbers in the brackets are the sequence of weed dominance value levels.

H0= control (manual weeding)
H1= glyphosate 540 g ae/Ha + 215 g a.i/Ha 2,4-D
H2= glyphosate 540 g ae/Ha + methyl metsulfuron 20g ai/Ha
H3= glyphosate 540 g ae/Ha + fluroxypir 50 g a.i/Ha
H4= glyphosate 540 g ae/Ha + indaziflam 50 g ai/Ha

H5= glyphosate 540 g ae/Ha + diuron 80g ai/Ha
H6= glyphosate 540 g ae/Ha + oxyfluorfen 240g a.i/Ha

3.2. Weed seed germination collected from circle weeding



H0= control (manual weeding); H1= glyphosate 540 g ae/Ha + 215 g a.i/Ha 2,4-D; H2= glyphosate 540 g ae/Ha + methyl metsulfuron 20g ai/Ha; H3= glyphosate 540 g ae/Ha + fluroxypir 50 g a.i/Ha; H4= glyphosate 540 g ae/Ha + indaziflam 50 g ai/Ha; H5= glyphosate 540 g ae/Ha + diuron 80 g ai/Ha; H6= glyphosate 540 g ae/Ha + oxyfluorfen 240g a.i/Ha

Figure 1. Seedlingsemerged from different soil depth collected from circles which have been previously treated with herbicides.

A. gangetica methods seeds can grow well at a depth of 0 to 1 cm of soil with the most amount on H6 and decreased at the next depth. *C. dactylon* seeds also grow a lot in H6 treatment at a depth of 1 to 3 cm. *E. indica* seeds are grown on each treatment less than the other weeds. *E. indica* grow most at H3 treatment at 0 to 1 cm depth. While *C. kyllingia* seeds can grow well on H6 treatment at 0 to 1 cm depth. Based on these results, it is confirmed that weed seeds were able to grow well at a soil depth of 0 to 3 cm but decreased in deeper soil layer. In addition, the highest number of seeds germinated and emerged was those in soil collected from H6 treatment. This suggests that the oxyfluorfen herbicide soil residue is low in the treatment. Whereas in the H4 treatment, only a few weed seedsgerminated indicating that the indaziflam residue was higher in the soil compared to other treatments. The number of *A. gangetica* seedlings also indicated that the weed seedbank is plentiful in the soil. The soil contained a large number of seeds for several weed species [3] and the determination of weed seed

banks is very important in the observation of population dynamics as well as in planning appropriate weed control.

The absence of seedlings on the soil treated glyphosate treatment combined with indaziflam indicated that the combination indaziflam was able to suppress overall weed growth. Indaziflam herbicide is a broad spectrum herbicide which controls broadleaves and grass with the mechanism of action inhibiting cellulosic biosynthesis [4]. Cellulosic biosynthesis is common in land plants. Therefore, herbicides with a working mechanism inhibiting cellulosic synthesis have a broad spectrum of weed control. Indaziflam has the ability to inhibit the growth of monocotyl and dicoty weeds. The large number of weed seeds grown on soils derived from the H6 treatment indicates that the application of glyphosate + oxyfluorfen herbicides is not able to kill the already mature weeds that will be the source of the seedbank. Thus the application of oxyfluorfen herbicide is preferable in the early phase of weed growth [5].

3.3. Seed germinationafter herbicide application

The germination of *E. indica* seeds introduced in various herbicide applied soil depths is shown in Figure 2. Herbicide treatments of H1, H2, H3, and H4, the majority of weed seeds grew in soil layer of 0 to 3 cm depth and decrease at the deeper depth. At the H5 treatment, no weeds grew on the soil from a depth of 0 to 5 cm but there are weeds of *E. indica* emerged on soil from a depth of 10to20 cm. While in the treatment of H6 and H7, weed seeds that grew on soil that emerged from a depth of 0 to 1 cm were less than in the deeper depth. The ability of weed seeds to emerge indicates the pattern of herbicide distribution in each herbicide treatment. Herbicide 2,4-D, methyl metsulfuron, and fluroxypir are widely dispersed at a depth of 0 to 3 cm and decrease their residue at a depth of 3 to 20 cm. Indaziflam still remains active in the soil and accumulates at a depth of 0 to 5 cm. While diuron and oxyfluorfen herbicides also accumulate a lot in the soil surface with a depth of 0 to 3 cm which then declined at the next depth.

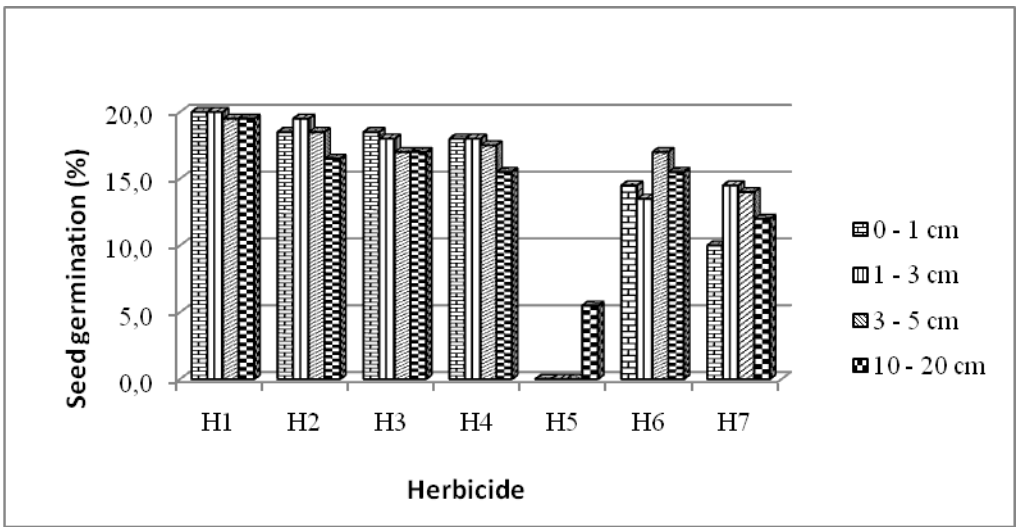


Figure 2. Percentage of *Eleusine indica* seed germinated in soil two weeks after spraying

The percentage of weed seeds growing on the soil of H6 and H7 treatments at 0 to 1 cm depth is lower than that of seedlings growing on H1, H2, H3, and H4treatments. This is probably due to oxyfluorfen tends to persist longer in the soil [5]. Diuron applied over the

surface of soil is not readily soluble in water which lead to its ability to withstand the washing and high absorption rates by soil colloids [6].

3.4. Germination of seed in various soil layer zone after herbicide application

One month after application, the soil sampling was carried out with a depth of 0 to 10 cm. Then the soil sample was placed in a growth plastic-box with size of 20 cm x 20 cm x 5 cm. The soil sample was distributed as tick of 2cm sterilized soil media in the growth box. The ability of seeds to germinate and emerge was observed at 3, 7 and 15 days after planting (Table 3).

Table 3. Germinating seed of selected weed species (*A.ganetica* and *E. indica*) planted at different depth of soil 3, 7, and 15 days after application (DAA)

No.	Depth of seed burial	3 DAA				7 DAA				15 DAA			
		A. gangetica		*E. indica*		*A. gangetica*		*E. indica*		*A. gangetica*		*E. indica*	
		.....(biji).....											
1	0 – 1 cm	6.00	A	1.67	a	18.33	A	18.33	a	20.00	a	19.67	a
2	1 – 2 cm	2.67	B	0.67	ab	18.67	A	12.33	b	19.67	a	17.00	a
3	2 – 3 cm	0.00	C	0.00	b	8.33	B	0.00	c	9.67	b	3.00	b
4	3 – 4 cm	0.00	C	0.00	b	1.33	C	0.00	c	2.67	c	0.00	b
5	4 – 5 cm	0.00	C	0.00	b	0.00	C	0.00	c	0.00	d	0.00	b
6	5 – 10 cm	0.00	C	0.00	b	0.00	C	0.00	c	0.00	d	0.00	b

Table 3 shows that weed seeds could emerge from soil at a depth ranging from 0 to 4 cm. On the other hand no seedling emerged from soil depth of 4 to 10 cm. Therefore the potential weed problems where *A. gangetica* and *E. indica* predominant species comes from seedbank in the soil layers 0 to 4 cm.

4. Conclusions

Glyphosate 720 g a.i/ha + indaziflam 50 g a.i/hareduced seedbank and regrowth of weeds. Up to 12 weeks after application glyphosate 720 g a.i/ha + indaziflam 50 g a.i/ha is 29.46% total weeds dry weight compared to manual weeding. The effect of herbicide application on changes on the weed composition and weed seedbank are affected by the characteristic of herbicides and weed response to herbicide application.

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