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Effect of the herbicide paraquat dichloride 276 g/L on weeds in the cultivation of immature Oil Palm Plants (*Elaeis guineensis* Jacq.)

Yayan Sumekar*, Dedi Widayat, Agus Susanto, Fatimah Yuliani
Faculty of Agriculture, Universitas Padjadjaran, Jl. R. Bandung-Sumedang, Jatinangor, Indonesia

Abstract
Oil palm (Elaeis guineensis Jacq.) is a plant from the plantation sector with high economic value. A severe problem in oil palm cultivation, especially in the immature plant phase, is the presence of weeds. Weeds in oil palms in the immature plant need to be controlled because, in this phase, oil palms have quite open spaces between plants, which results in weeds growing quite dominantly. One of the controls that can be carried out is chemical control using herbicides. Paraquat dichloride is a contact herbicide with a mode of action that inhibits photosystem I. It is included in contact herbicides, is non-selective, and is applied post-emergence. This research will run from December 2023 to April 2024 at the Palm Oil Plantation, Kec. Pakenjeng, Kab. Garut. The treatment design used a Randomized Experimental Design with seven treatments, namely: Paraquat dichloride 276 g/L dose 1.5 l/ha; 2.0 l/ha; 2.5 l/ha; 3.0 l/ha; 3.5 l/ha; manual weeding; and control (without treatment). Differences between treatments were tested using the F test and further tested using the Duncan test with a significance level of 5%. The research results show that application of the herbicide Paraquat dichloride starting from 1.5 l/ha can control weeds *Synedrella nodiflora, Cyperus rotundus, Oplismenus compositus, Pueraria montana* and weeds up to 8 w in total. Meanwhile, observations of the *Urena lobata* and *Strachytarpheta jamaicensis* weeds showed no significant differences between the control and manual weeding treatments.

Keywords: Weeds, Palm oil, Paraquat Dichloride 276 g/L, Efficacy

Introduction

Oil palm (Elaeis guineensis Jacq.) is a plant from the plantation sector with high economic value. Indonesia, the largest palm oil-producing country in the world, has a high potential for export activities (Patone *et al*., 2020) [11]. Oil palm plants can produce various products, including food, non-food, and waste. Food and non-food products are produced from Crude Palm Oil (CPO) and Kernel Palm Oil (KPO) (Larasati *et al*., 2016) [7]. Based on data from the Central Statistics Agency (2023), in 2022, the most significant contribution to palm oil exports will be CPO products at 9.40%, followed by KPO at 5.05%. Quoted from the Info Sawit (2024) [5] page, the level of CPO production in January 2024 increased compared to the previous month, reaching 4.232 million tons or an increase of 5.91% from 3.996 million tons.

Apart from increased palm oil production and exports in Indonesia, several factors can become severe problems in oil palm cultivation. Improper plant management during the immature plant phase is a crucial problem that needs attention, for example, planting, fertilizing, harvesting, and controlling pests, which include pests, diseases, and weed disorders (Prasetyo & Zaman, 2016) [12]. Control of pests, mainly weeds, in the immature oil palm plant needs to be controlled well because in the immature plant phase, oil palm has quite open spaces between plants because the plant canopies have not closed each other (Ugot *et al*., 2022) [17]. This causes the growth of weeds, which are quite dominant in that area. Its presence can cause competition or competition for CO2, air, sunlight, and nutrients needed by main plants to grow and develop to be hampered (Prayogo *et al*., 2017) [13].

Apart from inhibiting growth, uncontrolled weeds in oil palm plantations can economically impact crop production (Budi *et al*., 2020) [3]. Weeds in oil palm plants can be controlled using chemical methods by applying herbicides. The application was carried out on oil palm plants in the immature plant phase, namely spraying in the oil palm disk area. The paraquat dichloride is a contact herbicide that works by inhibiting photosystem I (Tiwari *et al*., 2019) [16]. This herbicide is a non-selective herbicide that can control all types of plants.

Therefore, proper paraquat herbicide application techniques are needed. Besides not influencing immature oil palm plants, inappropriate use of herbicides will cause side effects on humans (Muhartono *et al*., 2016) [8]. Paraquat is only active when applied to plant parts that have chlorophyll. It can be applied pre-growth or post-growth, effectively controlling broadleaf weeds and grass in oil palm plants (Anggriawan, 2017) [2]. Applying the herbicide paraquat dichloride causes plants to wilt quickly and dry out several hours after application, which begins with necrosis of the leaves within 1 - 3 days (Pujisiswanto *et al*., 2023) [14]. This research was conducted to determine the appropriate dose to control weeds in oil palm plantations with the herbicide paraquat dichloride with a formulation of 276 g/L. Apart from that, this research also aims to determine whether there are poisoning symptoms due to the herbicide's application to immature oil palm plants.

Methods

This research will run from December 2023 to April 2024. The research location is in the Palm Oil Plantation, Kec.Pakenjeng, Kab.Garut, West Java Province. The location is approximately 130 meters above sea level with an average soil pH of 5.5 and soil temperature of 27°C. The materials used in this research were a 2-year-old tenner variety oil palm (immature plant) and the herbicide tent one with the active ingredient paraquat dichloride 276 g/L. Meanwhile, the tools used in this research were a semi-

automatic knapsack sprayer with a T-jet nozzle, measuring cup, oven, scales, paper bags, scissors, stakes/marking wood, tape measure, hoe, writing utensils, quartz measuring 0.5 m x 0.5 m and cellphone.

This research used a Randomized Block Design of 7 treatments with four replications to obtain 28 experimental plots. The plot unit consists of weeds under three oil palm plants, each with a 1 – 1.5 m radius. The distance between treatment plot units is one oil palm plant. The palm oil planting distance is 9m x 9m x 9m. The treatments carried out can be seen in Table 1.

The herbicide is applied once the weed coverage in the oil palm plate area reaches 75% because paraquat herbicide is included in the post-emergence herbicide. It is applied by spraying herbicide according to the dose and plot in the immature plant oil palm plate area and carried out in the morning after the morning dew has disappeared or at a maximum of 11 am. The dry weight of weeds is observed twice, namely at 4 weeks and 8 weeks. Meanwhile, phytotoxicity observations were carried out at 2, 4, and 6 weeks.

Table 1: Codes and Treatment

No.	Code	Treatment	Dose (1/ha)
1	A	Herbicide Paraquat Dichloride 276 g/l	1,5
2	B	Herbicide Paraquat Dichloride 276 g/l	2,0
3	C	Herbicide Paraquat Dichloride 276 g/l	2,5
4	D	Herbicide Paraquat Dichloride 276 g/l	3,0
5	E	Paraquat Dichloride 276 g/l	3,5
6	F	Manual Weeding	-
7	G	Control	-

Results and discussion

Dry weight of *Synedrella nodiflora*

The variance analysis showed that the treatment dose of the herbicide paraquat dichloride 276 g/l significantly affected the dry weight of the weed *Synedrella nodiflora* at 8 weeks. Further test results from the dry weight data obtained can be seen in Table 2. At 8 weeks, the dry weight of treatments A to E showed significantly different results from the control treatment. It can be seen from Table 2 that the use of the herbicide paraquat dichloride 276 g/l at a dose of 1.5 l/ha was able to control the weed *Synedrella nodiflora*.

Table 2: Dry weight of *Synedrella nodiflora*

	Treatment	Dose l/ha	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat Dichloride 276 g/L	1,5	1,06 a	0,33 a
B	Paraquat Dichloride 276 g/L	2,0	0,08 a	0,10 a
C	Paraquat Dichloride 276 g/L	2,5	0,10 a	0,00 a
D	Paraquat Dichloride 276 g/L	3,0	0,17 a	0,04 a
E	Paraquat Dichloride 276 g/L	3,5	0,00 a	0,05 a
F	Manual Weeding		1,66 a	0,25 a
G	Control		1,29 a	1,89 b

Note: Results marked with the same letter in the same column indicate results that are not significantly different based on the Duncan Multiple Range Test at the 5% level.

Synedrella nodiflora, the dominant weed on immature oil palm cultivation land, is one of the weeds targeted by the herbicide paraquat dichloride. Paraquat dichloride 276 g/l can effectively control broadleaf weeds because of the contact application method. In line with Sidik's research (2020) [15], the herbicide paraquat dichloride at 375 – 750 g/ha effectively controls broadleaf weeds in immature oil palms.

Dry weight of *Urena lobata*

The results of the analysis of variance showed that the treatment dose of the herbicide paraquat dichloride of 276 g/l dry weight of the *Urena lobata* weed at 4 and 8 weeks did not show significantly different results in each treatment. Further test results from the dry weight data obtained can be seen in Table 3.

Table 3: Dry weight of Urena lobate

	Treatment	Dose l/ha	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat Dichloride 276 g/L	1,5	0,39 a	0,00 a
B	Paraquat Dichloride 276 g/L	2,0	0,00 a	0,07 a
C	Paraquat Dichloride 276 g/L	2,5	0,26 a	0,00 a
D	Paraquat Dichloride 276 g/L	3,0	0,14 a	0,04 a
E	Paraquat Dichloride 276 g/L	3,5	0,00 a	0,00 a
F	Manual Weeding		0,09 a	0,10 a
G	Control		1,44 a	0,00 a

Note: Results marked with the same letter in the same column indicate results that are not significantly different based on the Duncan Multiple Range Test at the 5% level.

Paraquat dichloride herbicide treatment at 4 and 8 weels has the potential to suppress weed growth, it can be seen in Table 3 at 4 weeks treatments B, D, and E have fewer amounts compared to the other treatments, although they are not significantly different either from the control or from control treatment. Similarly, with treatments A to E at 8 weeks, the dry weight of the *Urena lobata* weed produced was better when compared to manual weeding and control, although not significantly different.

Dry weight of *Cyperus rotundus*

The analysis of variance showed that the herbicide dose of 276 g/l paraquat dichloride significantly affected the dry weight of the weed Cyperus rotundus at 8 weeks. However, if we look at the further test data (Table 4) at 4 weeks, the herbicide dose treatment did not really affect the average dry weight of the *Cyperus rotundus*.

Table 4: Dry weight of Cyperus rotundus

	Treatment	Dose l/ha	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat Dichloride 276 g/L	1,5	0,23 a	0,08 a
B	Paraquat Dichloride 276 g/L	2,0	0,05 a	0,02 a
C	Paraquat Dichloride 276 g/L	2,5	0,05 a	0,22 a
D	Paraquat Dichloride 276 g/L	3,0	0,05 a	0,18 a
E	Paraquat Dichloride 276 g/L	3,5	0,20 a	0,21 a
F	Manual Weeding		0,51 a	0,15 a
G	Control		0,16 a	1,02 b

Note: Results marked with the same letter in the same column indicate results that are not significantly different based on the Duncan Multiple Range Test at the 5% level.

Table 4 shows that the 276 g/L paraquat dichloride treatment at 8 weeks starting at a dose of 1.5 l/ha to 3.5 l/ha gave a lower average dry weight of weeds and significantly differed from the control. This shows that the herbicide treatment of 276 g/L paraquat dichloride at a 1.5 to 3.5 l/ha dose effectively controls the weed *C. rotundus. C.rotundus* weed is included in the weeds that grow widely and are difficult to eradicate. Agree with Adiwijaya & Lusiana (2022) [1] that *C. rotundus* weed is difficult to control because it can survive in various environmental conditions. According to Kastanja (2011) [6], the *C. rotundus* weed must be controlled using herbicides because it is classified as a weed that can survive extreme weather. Even though observations at 4 weeks treatments did not show any

fundamental differences, treatments A to E (1.5 – 3.5 l/ha) had dry weight results that were smaller than manual weeding and control.

Dry weight of *Oplismenus compositus*

The analysis of variance showed that the herbicide dose of 276 g/l paraquat dichloride effectively controlled the Oplismenus compositus weed at 4 to 8 weeks It can be seen that the treatment with herbicide doses A to E (1.5 - 3.5 l/ha) had a smaller dry weight compared to manual weeding and control. Analysis of variance data can be seen in Table 5.

Table 5: Dry weight of *Oplismenus compositus*

	Treatment	Dose l/ha	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat Dichloride 276 g/L	1,5	0,16 a	0,00 a
B	Paraquat Dichloride 276 g/L	2,0	0,45 a	0,18 a
C	Paraquat Dichloride 276 g/L	2,5	0,00 a	0,02 a
D	Paraquat Dichloride 276 g/L	3,0	0,00 a	0,03 a
E	Paraquat Dichloride 276 g/L	3,5	0,00 a	0,08 a
F	Manual Weeding		0,11 a	0,23 a
G	Control		3,82 b	0,65 b

Note: Results marked with the same letter in the same column indicate results that are not significantly different based on the Duncan Multiple Range Test at the 5% level.

Based on Table 5, at 4 weeks to 8 weeks, the treatment produced a dry weight significantly different from the control treatment. It can be concluded that the herbicide paraquat dichloride 276 g/L can suppress the weed *Oplismenus compositus*. It is suspected that the active herbicide ingredient contained can still survive up to 8 weeks to inhibit the growth of the weed *O. compositus*, which is included in the grass weed group. In line with research by Giraldi & Rahmadi (2023) [4], the herbicide paraquat dichloride at a dose of 310.5 – 621 g/ha can control grass-class weeds up to 8 weeks. Treatment A with a dose of 1.5 l/ha can be effective because it can suppress the growth of *O.compositus* weeds. All herbicide treatments had an average dry weight of *O. compositus* weeds that was much lower and significantly different from the control treatment.

Dry weight of *Pueraria montana*

The analysis of variance showed that the treatment dose of the herbicide paraquat dichloride 276 g/l had a significant effect on the dry weight of the Pueraria montana weed at 4 - 8 weeks, which can be seen in Table 6.

Table 6: Dry weight of Pueraria montana

	Treatment	Dose l/ha	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat Dichloride 276 g/L	1,5	0,13 ab	0,13 a
B	Paraquat Dichloride 276 g/L	2,0	1,12 b	0,61 ab
C	Paraquat Dichloride 276 g/L	2,5	0,01 a	0,03 a
D	Paraquat Dichloride 276 g/L	3,0	0,00 a	0,00 a
E	Paraquat Dichloride 276 g/L	3,5	0,00 a	0,06 a
F	Manual Weeding		0,08 a	0,04 a
G	Control		1,05 b	1,23 b

Note: Results marked with the same letter in the same column indicate results that are not significantly different based on the Duncan Multiple Range Test at the 5% level.

The results of further test analysis in Table 6 show that at 4 weeks and 8 weeks, the treatment dose of paraquat dichloride herbicide was effective in controlling the Pueraria montana weed starting from a dose of 2.5 l/ha. This is indicated by the average dry weight of P. montana weeds which is lower and significantly different from the control treatment.

Total weed dry weight

The total dry weight of weeds is the constant dry weight of the number of all weed species growing and found on the experimental land during the observation. Based on the results of the analysis of variations in the dry weight of total weeds, it shows that the treatment dose of 276 g/L paraquat dichloride herbicide had a significant effect on the dry weight of total weeds at 4 weeks to 8 weeks (can be seen in Table 7).

Table 7: Total Weed Dry Weight

	Treatment	Dose l/ha	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat Dichloride 276 g/L	1,5	4,41 c	0,61 a
B	Paraquat Dichloride 276 g/L	2,0	4,26 c	1,09 a
C	Paraquat Dichloride 276 g/L	2,5	1,17 ab	0,34 a
D	Paraquat Dichloride 276 g/L	3,0	1,86 ab	0,33 a
E	Paraquat Dichloride 276 g/L	3,5	0,35 a	0,44 a
F	Manual Weeding		2,87 bc	0,80 a
G	Control		10,05 d	5,76 b

Note: Results marked with the same letter in the same column indicate results that are not significantly different based on the Duncan Multiple Range Test at the 5% level.

Further test data in Table 7 on the observation of total weed dry weight of 4 weeks at a dose of 1.5 l/ha can be stated as an effective dose for controlling total weeds in TBM oil palm plantations because it has a notation that is significantly different from the control treatment. However, among all the treatments tested at each observation, treatment E, namely with a dose of 276 g/L paraquat dichloride herbicide of 3.5 l/ha, was the best dose in suppressing weed growth because it could reduce the dry weight so that it was smaller than the control and manual weeding as stated by Pasaribu *et al.* (2017) [10] that weed control can be said to be effective when the average dry weight of weeds is lower compared to control and manual weeding. This proves that the herbicide treatment of 276 g/L paraquat dichloride at a dose of 1.5 l/ha to 3.5 l/ha effectively controls weeds in immature oil palm plantations. These results align with research by Pujisiswanto *et al.* (2023) [14], which states that paraquat dichloride at a dose of 621 – 1,242 g/ha effectively controls total weed growth. Other research also states that the herbicide paraquat dichloride at a dose of 375 – 760 g/ha can control total weeds on immature oil palm discs compared to the control treatment (Sidik, 2020) [15]. The total weeds found included puzzle weeds, grasses, and broad leaves. Paraquat dichloride is a contact herbicide that can directly affect plant parts (mainly leaves) that are hit by the herbicide spray. This makes the herbicide paraquat dichloride effective in controlling weeds, grasses, especially broadleaf weeds. In line with research by Murti *et al*. (2015) [9], the use of paraquat dichloride can control broadleaf weeds.

Phytotoxicity of TBM oil palm plants

The results listed in Table 8 show that phytotoxicity did not occur at 2, 4, and 6 weeks, as seen in the scoring results, which were not significantly different. These results prove that the herbicide paraquat dichloride 276 g/L from the smallest to the most significant dose does not cause symptoms of damage due to the application of the herbicide. This can be seen based on observations made visually by producing a poisoning score, which can be seen in Table 8, namely 0. This shows no symptoms of poisoning caused by herbicides that disturb the main crop, namely immature oil palm.

Table 8: Palm Oil Phytotoxicity

	Treatment	Dose l/ha	2 Weeks	4 Weeks	6 Weeks
A	Paraquat Dichloride 276 g/L	1,5	0	0	0
B	Paraquat Dichloride 276 g/L	2,0	0	0	0
C	Paraquat Dichloride 276 g/L	2,5	0	0	0
D	Paraquat Dichloride 276 g/L	3,0	0	0	0
E	Paraquat Dichloride 276 g/L	3,5	0	0	0
F	Manual Weeding		0	0	0
G	Control		0	0	0

Note: Results marked with the same letter in the same column indicate results that are not significantly different based on the Duncan Multiple Range Test at the 5% level.

Paraquat herbicide is a contact herbicide that is only active on plant organs with green leaf substances. Therefore, the application method also plays an essential role in weed poisoning caused by herbicides. In line with Avun (in Umiyati *et al*., 2019) [18], the correct application of herbicides is to increase direct contact with weeds and reduce contact with the main plant.

In this research, herbicide was applied to the immature oil palm disc area. The observation results, which show no poisoning in immature oil palm plants, prove that the herbicide application was carried out on target, namely hitting the target weeds on the plate only and not hitting the main plant. This aligns with research conducted by Pujisiswanto *et al*. (2023) [14] that applying the herbicide paraquat dichloride to immature oil palms does not cause symptoms of poisoning in immature oil palm plants.

Conclusion

Based on the results of this experiment, various application doses of the herbicide Paraquat dichloride 276 g/l are effective in controlling weeds up to 8 weeks and have a good effect on plants. Application of the herbicide Paraquat 276 g/l with doses starting from 1.5 l/ha can control weeds *Synedrella nodiflora*, *Cyperus rotundus, Oplismenus compositus*, *Pueraria montana* and weeds up to 8 weeks in total. Meanwhile, *Paspalum conjugatum* and *Cyperus killingia* weeds can only be controlled up to 4 weeks. Meanwhile, observations of the *Urena lobate* and *Strachytarpheta jamaicensis* weeds showed no significant differences between the control and manual weeding treatments.

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