



Effect of herbicide paraquat dichloride 135 g/l on the growth of weeds and immature Arabica coffee (*Coffea arabica*) plants

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Abstract

Arabica coffee (*Coffea arabica*) is one of the mainstay commodities in the Indonesian plantation sector. The problem that often arises in coffee plantation is the presence of weeds, especially in the immature phase. Weeds on immature coffee plantations are causing harm because they can reduce the quality of results when they come to mature phase. One of the most effective and efficient weed controls is by applying herbicides. Paraquat dichloride is a contact herbicide that is applied post-emergence, non-selective and has the characteristic of reacting to green leaf matter because the mechanism of this herbicide interferes with the photosystem I. The research was conducted in January – April 2024 whereas arabica coffee is commonly planted by farmers in Tanjung Karya Village, Samarang District, Garut Regency. The treatment design used Randomized Block Design (RBD) with 7 treatments which are Paraquat dichloride 135 g/l at 2.25, 3.00, 3.75, 4.50, and 5.75 l/ha, manual weeding, and control (no treatment). The result of the experiment showed that the herbicide active ingredient Paraquat dichloride 135 g/l doses 2.25 until 5.25 l/ha effectively controlled *Ageratum conyzoides*, *Synedrella nodiflora*, *Setaria plicata*, *Alternanthera sessilis*, *Commelina benghalensis*, another weeds, and total weeds up to 8 weeks after application and had a good effect on the growth without causing toxic effects on coffee plantations. On the other hand, *Paspalum conjugatum* and *Cyperus killingia* effectively controlled up to 4 weeks.

Keywords: Paraquat dichloride 135 g/l, weeds, efficacy, coffee

Introduction

Coffee is one of the plantation commodities with the highest demand in both local and international markets and often referred as a mainstay commodity in the Indonesian plantation sector. Unfortunately, Indonesia's overall coffee production decreased by 1.43 percent, starting from 786.19 thousand tons in 2021 to 774.96 thousand tons (Badan Pusat Statistik, 2023) [4]. In Indonesia, the most often cultivated types of coffee are robusta and arabica. Quoted from Harum (2022) [7], in general the production of robusta coffee plants is higher than arabica because arabica type cannot grow anywhere or in the highlands.

The decreased of coffee production can be influenced by several factors, including a lack of cooperation with other sectors, fewer workers, weather, and poor maintenance (Septiani & Kawuryan, 2021) [17]. Good and optimal maintenance of coffee plants is needed to increase production and quality that is able to compete in the export market. Weed control is one of the important things in maintaining coffee plants, especially in the immature phase because in this phase there is more weed growth.

The reduction in yield quality is caused by contamination of allelochemical compounds by weeds which can inhibit plant metabolism (Harahap *et al.*, 2022) [6]. The presence of weeds in coffee plantations will affect in competition for nutrients, resulting in suboptimal plant yields (Kilkoda *et al.*, 2015) [8]. According to Widiyanti (2013) [24], weeds in coffee plantations can reduce bean production by 35 percent. Weeds control can be done in preventive, physical, biological, and chemical control using herbicides (Ratnawati, 2017) [14]. Quoted from Sigalingging *et al.* (2014), chemical control with herbicides is a method that often used because it is more efficient and effective in controlling weeds.

The use of Paraquat dichloride herbicides in Indonesia is often used to control weeds in plantations areas such as coffee, palm oil, rubber, coco, sugar cane, etc. (Nurulalia *et al.*, 2021) [11]. Paraquat dichloride herbicide is a herbicide that is applied post-emergence or applied when weeds have grown and it's a contact herbicide that is capable of killing plant tissue directly and non-selective. According to Sumekar *et al.* (2021) [21, 22] the mode of action this herbicide is by interfering with the photosystem I process so that the reduction of the NADP compound to NADPH does not occur, but produces a radical compound in the form of hydrogen peroxide. These compounds then damage cell membranes and cause tissue death in plants.

The effectiveness of an herbicide in controlling weeds depends on the dose used. The right dose of herbicide can control weed growth optimally, however if the dose used is not appropriate it will reduce the effectiveness of the herbicide. Beside that, the impact of inappropriate herbicide doses used can inflict in phytotoxicity (poisoning) non-target plants (Panjaitan & Nugroho, 2020) [13]. This study aims to determine the appropriate dose to control weeds in coffee plantations with the active ingredient Paraquat dichloride herbicide 135 g/l. Apart from that, this research also aims to determine whether there are symptoms of poisoning due to the application of the herbicide to immature coffee plants.

Methods

The research was conducted in January – April 2024 whereas arabica coffee is commonly planted by farmers in Tanjung Karya Village, Samarang District, Garut Regency. The research location is at an altitude 1124 meters above sea level with an average temperature ranging from 17 - 30°C. Materials that need to be prepare in this research are coffee plant variety S 795 in immature phase 2 years, and herbicide

with active ingredient Paraquat dichloride 135 g/l. Meanwhile, the tools used were semi-automatic knapsack sprayers and T-jet nozzles, measuring cups, 0.5 m x 0.5 m quadrants, oven, analytical scales, paper envelopes, office stationery, and cameras for documentation.

This experiment used Randomized Block Design (RBD) method with 7 treatments repeated 4 times, resulting in a total of 28 experimental plots. Each experimental plot had a size 15 m x 2 m with spacing 2.5 m x 2.5 m. The observed treatment can be seen in Table 1.

Table 1: Herbicide treatment with the active ingredient Paraquat dichloride 135 g/l

Kode	Treatment	Dosage (l/ha)
A	Herbicide with Paraquat dichloride 135 g/l active ingredient	2,25
B	Herbicide with Paraquat dichloride 135 g/l active ingredient	3,00
C	Herbicide with Paraquat dichloride 135 g/l active ingredient	3,75
D	Herbicide with Paraquat dichloride 135 g/l active ingredient	4,50
E	Herbicide with Paraquat dichloride 135 g/l active ingredient	5,25
F	Manual weeding	-
G	Control	-

Application of herbicide Paraquat dichloride 135 g/l is can be held when weed coverage reaches 75 percent because it is a post-emergence herbicide. The herbicide was sprayed using a sprayer on the weeds in the experimental plot according to the dosage. The sampling of dry weight of weeds was conducted at 4 weeks and 8 weeks. Meanwhile, phytotoxicity observation were held at 2 weeks, 4 weeks, and 6 weeks.

Results and Discussion

Dry weight of *Ageratum conyzoides*

The presence of *A. conyzoides* weeds can disrupt agricultural cultivation, particularly in plantation areas

(Nduru *et al.*, 2023) [10]. Based on the statistical test results shown in Table 2, the treatment with Paraquat dichloride 135 g/l had a significant effect on the dry weight of *A. conyzoides* weeds at 4 weeks and 8 weeks, with dosages ranging from 2.25 l/ha to 5.25 l/ha, and manual weeding resulted in lower dry weights compared to the control. These findings are consistent with the research by Sumekar *et al.* (2021) [21, 22], which indicated that Paraquat dichloride effectively controlled *A. conyzoides* weeds from 4 weeks to 8 weeks. *A. conyzoides* is a broadleaf weed species with larger leaf surfaces capable of capturing herbicide particles more easily, making it easier to control, although it grows very rapidly (Adiwijaya & Lusiana, 2022) [1].

Table 2: Observation of the dry weight of *Ageratum conyzoides*

	Treatment	Dosage (l/ha)	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat dichloride 135 g/l	2,25	1,17 a	1,26 b
B	Paraquat dichloride 135 g/l	3,00	0,73 a	0,96 b
C	Paraquat dichloride 135 g/l	3,75	0,38 a	0,53 ab
D	Paraquat dichloride 135 g/l	4,50	0,20 a	0,41 ab
E	Paraquat dichloride 135 g/l	5,25	0,00 a	0,15 a
F	Manual weeding	-	0,85 a	1,21 b
G	Control	-	4,78 b	2,35 c

Note: The same letters indicate results that are not significantly different based on Duncan's test at the 5% level

Dry weight of *Synedrella nodiflora*

Based on the statistical test results in Table 3, the treatment with Paraquat dichloride 135 g/l had a significant effect on the dry weight of *S. nodiflora* weeds at 4 weeks and 8 weeks. At 4 weeks, the effective dosage started at 3.00 l/ha, and at 8 weeks, it started at 3.75 l/ha, both showing lower average values compared to the control. This aligns with the

research by Sari (2020) [16], which found that Paraquat dichloride at doses starting from 3.00 l/ha, equivalent to 405 g/ha, effectively controlled *S. nodiflora* weeds up to 6 weeks. *S. nodiflora* reproduces through seeds and has a high adaptability to the environment, leading to a faster regrowth rate (Dahlianah, 2019) [5]

Table 3: Observation of the dry weight of *Synedrella nodiflora*

	Treatment	Dosage (l/ha)	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat dichloride 135 g/l	2,25	1,38 bc	2,53 ab
B	Paraquat dichloride 135 g/l	3,00	1,05 ab	2,14 ab
C	Paraquat dichloride 135 g/l	3,75	0,70 ab	0,43 a
D	Paraquat dichloride 135 g/l	4,50	0,00 a	0,24 a
E	Paraquat dichloride 135 g/l	5,25	0,00 a	0,22 a
F	Manual weeding	-	2,79 bc	4,13 b
G	Control	-	4,05 c	5,35 b

Note: The same letters indicate results that are not significantly different based on Duncan's test at the 5% level

Dry weight of *Setaria plicata*

Setaria plicata is a perennial grass weed commonly found in shaded areas, reproducing through seeds and stolons (Simangunsong *et al.*, 2018) [19]. According to the data in Table 4, the treatment with Paraquat dichloride 135 g/l significantly affected the dry weight of *S. plicata* weeds at 4

weeks and 8 weeks. Dosages ranging from 2.25 l/ha to 5.25 l/ha resulted in lower average values compared to manual weeding and control. These findings are consistent with the research by Umiyati *et al.* (2018) [23], which found that grass weeds can be effectively controlled up to 8 weeks with doses starting from 3.00 l/ha, equivalent to 414 g/ha.

Table 4: Observation of the dry weight of *Setaria plicata*

	Treatment	Dosage (l/ha)	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat dichloride 135 g/l	2,25	1,90 a	3,04 a
B	Paraquat dichloride 135 g/l	3,00	1,68 a	2,33 a
C	Paraquat dichloride 135 g/l	3,75	1,58 a	2,16 a
D	Paraquat dichloride 135 g/l	4,50	1,49 a	1,77 a
E	Paraquat dichloride 135 g/l	5,25	0,78 a	1,66 a
F	Manual weeding	-	4,13 b	6,27 b
G	Control	-	6,31 b	10,47 b

Note: The same letters indicate results that are not significantly different based on Duncan's test at the 5% level

Dry weight of *Alternanthera sessilis*

According to the data in Table 5, the treatment with Paraquat dichloride 135 g/l had a significant effect on the dry weight of *Alternanthera sessilis* at 4 weeks and 8 weeks. Dosages ranging from 2.25 l/ha to 5.25 l/ha resulted in

lower values compared to manual weeding and the control at both 4 weeks and 8 weeks. This is consistent with the research by Sumekar *et al.* (2021) [21, 22], which found that Paraquat dichloride treatment effectively controlled *A. sessilis* up to 6 weeks.

Table 5: Observation of the dry weight of *Alternanthera sessilis*

	Treatment	Dosage (l/ha)	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat dichloride 135 g/l	2,25	0,34 a	0,65 a
B	Paraquat dichloride 135 g/l	3,00	0,31 a	0,62 a
C	Paraquat dichloride 135 g/l	3,75	0,25 a	0,50 a
D	Paraquat dichloride 135 g/l	4,50	0,00 a	0,44 a
E	Paraquat dichloride 135 g/l	5,25	0,00 a	0,14 a
F	Manual weeding	-	0,90 b	0,77 ab
G	Control	-	1,21 b	1,55 b

Note: The same letters indicate results that are not significantly different based on Duncan's test at the 5% level

The difference in the average dry weight values of weeds resulting from herbicide treatment compared to manual weeding is suspected to be due to the rapid proliferation of *A. sessilis*, as they reproduce through seeds (Sumekar *et al.*, 2021) [21, 22]. Therefore, the ineffectiveness of manual weeding in controlling *A. sessilis* may be caused by the weed seeds that settle in the soil and germinate.

Dry weight of *Commelina benghalensis*

Based on the data in Table 6, it is shown that the treatment with Paraquat dichloride herbicide 135 g/l significantly

affected the dry weight of *Commelina benghalensis* at 4 weeks with dosages ranging from 2.25 l/ha to 5.25 l/ha, and manual weeding had lower values compared to the control. At 8 weeks, all herbicide treatments except for doses of 4.50 l/ha and 5.25 l/ha, as well as manual weeding, did not significantly differ from the control. This statement aligns with the research findings of Sulistyono *et al.*, (1999) [20], which stated that the application of Paraquat dichloride herbicide could suppress the dry weight of *C. benghalensis* weeds up to 8 weeks.

Table 6: Observation of the dry weight of *Commelina benghalensis*

	Treatment	Dosage (l/ha)	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat dichloride 135 g/l	2,25	0,25 a	1,10 ab
B	Paraquat dichloride 135 g/l	3,00	0,15 a	0,97 ab
C	Paraquat dichloride 135 g/l	3,75	0,00 a	0,65 ab
D	Paraquat dichloride 135 g/l	4,50	0,00 a	0,45 a
E	Paraquat dichloride 135 g/l	5,25	0,00 a	0,26 a
F	Manual weeding	-	0,17 a	1,19 ab
G	Control	-	1,14 b	1,61 b

Note: The same letters indicate results that are not significantly different based on Duncan's test at the 5% level

Dry weight of *Paspalum conjugatum*

According to the data in Table 7, it is shown that the treatment with Paraquat dichloride herbicide 135 g/l significantly affected the dry weight of *Paspalum*

conjugatum at 4 weeks with dosages ranging from 2.25 l/ha to 5.25 l/ha, indicating that the average dry weight value of *P. conjugatum* weeds was lower than that of manual weeding and the control. These results are consistent with

the statement in the research by Murti *et al.* (2015)^[9], which stated that Paraquat dichloride herbicide could control grass

weed species up to 4 weeks with doses starting from 3.00 l/ha, equivalent to 414 g/ha.

Table 7: Observation of the dry weight of *Paspalum conjugatum*

	Treatment	Dosage (l/ha)	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat dichloride 135 g/l	2,25	0,43 ab	1,12 a
B	Paraquat dichloride 135 g/l	3,00	0,31 ab	1,07 a
C	Paraquat dichloride 135 g/l	3,75	0,25 a	1,05 a
D	Paraquat dichloride 135 g/l	4,50	0,03 a	0,91 a
E	Paraquat dichloride 135 g/l	5,25	0,00 a	0,77 a
F	Manual weeding	-	0,80 bc	0,96 a
G	Control	-	1,43 c	1,83 a

Note: The same letters indicate results that are not significantly different based on Duncan’s test at the 5% level

P. conjugatum weeds belong to the group of annual grasses capable of reproducing generatively through seeds and vegetatively, characterized by apical dominance, allowing the remaining vegetative organs in the soil to regrow due to the availability of water (Zulhusni *et al.*, 2023)^[25]. Additionally, *P. conjugatum* can grow at altitudes ranging from 0 to 1700 meters above sea level, making it highly suitable for regrowth in research locations with an elevation of 1124 meters above sea level (Palandi, 2022)^[12].

Dry weight of *Cyperus killigia*

Based on the data in Table 8, it is shown that the treatment with Paraquat dichloride herbicide 135 g/l significantly affected the dry weight of *Cyperus killigia* at 4 weeks with dosages ranging from 2.25 l/ha to 5.25 l/ha, while manual weeding showed lower average dry weight values compared to the control. This statement is consistent with the research by Sidik *et al.* (2020)^[18], which stated that all levels of Paraquat dichloride herbicide treatment were effective in controlling sedge weeds. However, at 8 and 12 weeks, all herbicide treatments were ineffective in controlling *C. killigia* and *Cyperus rotundus*.

Table 8: Observation of the dry weight of *Cyperus killigia*

	Treatment	Dosage (l/ha)	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat dichloride 135 g/l	2,25	0,43 a	1,08 a
B	Paraquat dichloride 135 g/l	3,00	0,36 a	1,08 a
C	Paraquat dichloride 135 g/l	3,75	0,38 a	1,03 a
D	Paraquat dichloride 135 g/l	4,50	0,28 a	1,00 a
E	Paraquat dichloride 135 g/l	5,25	0,02 a	0,93 a
F	Manual weeding	-	0,58 a	1,22 a
G	Control	-	5,00 b	1,60 a

Note: The same letters indicate results that are not significantly different based on Duncan’s test at the 5% level

Dry weight of other weeds

The dry weight of other weeds refers to the average values obtained from observations on the dry weight of weed species other than the dominant and commonly found weed species. Other weed species growing in the research area include *Galinsonga quadriradiata*, *Drymaria cordata*,

Amaranthus spinosus, *Artemis vulgaris*, *Commelina diffusa*, *Euphorbia heterophylla*, *Marsypianthes chamaedryst*, and *Mimosa pudica*, which belong to the broadleaf weed group, *Cyperus rotundus*, classified as sedge weeds, and *Digitaria ciliaris* and *Cynodon dactylon*, which are classified as grass weeds.

Table 9: Observation of the dry weight of other weeds

	Treatment	Dosage (l/ha)	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat dichloride 135 g/l	2,25	1,29 a	1,20 ab
B	Paraquat dichloride 135 g/l	3,00	1,14 a	0,99 ab
C	Paraquat dichloride 135 g/l	3,75	1,22 a	0,68 ab
D	Paraquat dichloride 135 g/l	4,50	0,96 a	0,38 a
E	Paraquat dichloride 135 g/l	5,25	0,68 a	0,24 a
F	Manual weeding	-	2,66 ab	1,61 b
G	Control	-	3,67 b	1,65 b

Note: The same letters indicate results that are not significantly different based on Duncan’s test at the 5% level

Based on the data in Table 9, it is shown that the treatment with Paraquat dichloride herbicide 135 g/l significantly affected the dry weight of other weeds at 4 weeks and 8 weeks with dosages ranging from 2.25 l/ha to 5.25 l/ha,

indicating that the average dry weight of other weeds was lower than the control. However, at 8 weeks, only doses of 4.50 l/ha to 5.25 l/ha showed significant differences. This statement aligns with the research by Sumekar *et al.* (2021)

[21, 22], which found that the application of Paraquat dichloride herbicide could control other weeds consisting of broadleaf and sedge weed groups with doses starting from 3.00 l/ha at both 4 weeks and 8 weeks.

Dry weight of total weeds

Based on the data in Table 10, it is shown that the treatment with Paraquat dichloride herbicide 135 g/l significantly

affected the total dry weight of weeds at 4 weeks and 8 weeks with dosages ranging from 2.25 l/ha to 5.25 l/ha. Manual weeding showed lower average total dry weight values compared to the control. These results are in accordance with the statement by Anggriawan *et al.* (2018) [3], which found that Paraquat dichloride herbicide, with doses starting from 3.00 l/ha or approximately 414 g/ha, effectively controlled total weeds growth up to 8 weeks.

Table 10: Observation of the dry weight of total weeds

	Treatment	Dosage (l/ha)	Dry weight (g)	
			4 Weeks	8 Weeks
A	Paraquat dichloride 135 g/l	2,25	6,99 ab	11,97 c
B	Paraquat dichloride 135 g/l	3,00	5,12 ab	10,15 bc
C	Paraquat dichloride 135 g/l	3,75	4,43 ab	7,02 abc
D	Paraquat dichloride 135 g/l	4,50	2,91 a	5,59 ab
E	Paraquat dichloride 135 g/l	5,25	1,48 a	4,34 a
F	Manual weeding	-	10,86 b	17,35 d
G	Control	-	29,93 c	26,40 e

Note: The same letters indicate results that are not significantly different based on Duncan’s test at the 5% level; WEEKS = weeks after application

Phytotoxicity of immature coffee plants

Based on the observations, it can be inferred that the application of herbicide with doses ranging from 2.25 l/ha to 5.25 l/ha containing the active ingredient Paraquat

dichloride 135 g/l did not exhibit any signs of toxicity to immature coffee plants at 2, 4, and 6 weeks, as indicated in Table 11.

Table 11: Data keracunan pada tanaman kopi TBM

	Treatment	Dosage (l/ha)	Tingkat Keracunan		
			2 Weeks	4 Weeks	6 Weeks
A	Paraquat dichloride 135 g/l	2,25	0	0	0
B	Paraquat dichloride 135 g/l	3,00	0	0	0
C	Paraquat dichloride 135 g/l	3,75	0	0	0
D	Paraquat dichloride 135 g/l	4,50	0	0	0
E	Paraquat dichloride 135 g/l	5,25	0	0	0
F	Manual weeding	-	0	0	0
G	Control	-	0	0	0

There are no phytotoxicity symptoms in the application of herbicide with 135 g/l active ingredients which are caused by the timing of application is held when the plants in immature phase 2 year or sufficiently large, thereby reducing the risk of plant exposure to the herbicide. According to Akram *et al.* (2019) [2], phytotoxicity of plants caused by herbicides depends on the method of application, environmental conditions during application, and the height of the plants. Smaller plants are more likely to experience herbicide poisoning compared to larger ones.

Conclusion

Based on the results of this experiment, it can be concluded that various dosages of Paraquat dichloride 135 g/l herbicide are effective in controlling weeds up to 8 weeks and have a positive impact on the plants (not causing phytotoxicity). The application of Paraquat 135 g/l herbicide at doses starting from 2.25 l/ha was able to control *Ageratum conyzoides*, *Setaria plicata*, *Alternanthera sessilis*, *Commelina benghalensis*, other weeds, and total weeds up to 8 weeks. However, *Paspalum conjugatum* and *Cyperus killingia* weeds could only be controlled up to 4 weeks.

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