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Effectiveness of IPA Glyphosate 245 g/l herbicide against weeds on immature Coffee Arabika Plantations (*Coffea arabica*)

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Abstract
The maintenance activity that must be carried out on immature coffee plants is weed control. Weeds can cause problems in immature coffee plantations. Controlling weeds in plantation areas will be more efficient and effective by using herbicides. IPA Glyphosate herbicide have a broad spectrum and often used to control weeds in plantation crops. The IPA Glyphosate herbicide can inhibit the action of the EPSPS enzyme. This research aims to determine the effectiveness and dose of the isopropylamine glyphosate 245 g/l herbicide in controlling various types of weeds in immature coffee plants. The research was conducted from January to April 2024 at the people's coffee plantation, Tanjung Karya Village, Samarang District, Garut Regency, West Java Province. The experiment used a Randomized Block Design (RBD) with seven treatments and four replications, so that 28 experimental plots were obtain. The treatment included the application of isopropylamine (IPA) glyphosate 245 g/l herbicide at a dose of 2.25; 3.00; 3.75; 4.50; 5.25 l/ha; manual weeding; and control. The experimental results showed that the herbicide containing the active ingredient isopropylamine (IPA) glyphosate 245 g/l starting at a dose of 2.25 – 5.25 l/ha was effective in controlling the weeds *Setaria plicata*, *Marsypianthes chamaedrys*, *Drymaria cordata*, *Artemisia vulgaris*, *Ageratum conyzoides*, *Galinsoga parviflora*, other weeds, and total weeds up to 12 Weeks After Application (WAA) without causing phytotoxicity to immature coffee plants.

Keywords: Coffee, efficacy, IPA Glyphosate 245 g/l, weed

Introduction

Coffee is one of the main plantation commodities that has great potential for development. Database in BPS (2023) shows that the amount of Indonesian coffee production has fluctuated, in 2021 there was an increase in production of around 3.12%, but in the following year it experienced a decline. Initially in 2021 total production reached 786.19 thousand tons, then in 2022 it fell to 774.96 thousand tons.

Plant maintenance activities can help in increasing production. An important maintenance activity to carry out is weed control, especially when the plant is in the immature phase. According to Rodrigueset *et al*. (2020) [9] coffee plants in the first two years after planting will grow slowly and the canopy of the coffee plants is still not closed tightly so that the rows of plants cannot be shaded or cover the entire surface area of the soil. Sunlight can be used by weed seeds to germinate. Weeds that grow and develop well cause high weed populations on immature planting land (Tjitrosoedirdjo *et al*., 1984) [13]. Weeds can disturb human interests because they make it difficult for farmers to carry out maintenance, mobility becomes limited, and it is difficult to navigate the land because there are weeds that grow thickly or have thorns around the plants (Dani & Arifin, 2023 [2]; Umiyati & Widayat, 2017) [15]. In addition, weeds and immature coffee plants will compete for nutrients, growing space, water and light.

Herbicides containing the active ingredient isopropylamine glyphosate are herbicides that are often used to control weeds. Its non-selective nature means this herbicide has a broad control spectrum and can control various types of weeds (Iskandar & Yudiawati, 2022) [3]. According to Priyatno *et al*. (2019) [7s] isopropylamine glyphosate herbicide is systemic, the results of the spray will be absorbed and then translocated throughout the weed's body so that its killing power becomes more certain. The way the glyphosate herbicide works is to inhibit the action of the EPSPS enzyme (*5-enolpyruvylshikimate-3- phosphate synthesis*) which causes weeds to be unable to synthesize aromatic amino acids (tryptophan, phenylalanine and tyrosine), weeds will lack amino acids in the growth process (Priyatno *et al*., 2019) [7]. The symptoms are chlorosis occurring on young leaves and growing points, followed by necrosis 4-7 days after application (Priyatno *et al*., 2019) [7]. However, symptoms in annual weeds can be seen 10 days or more after application (Mangoensoekarjo & Soejono, 2015) [6].

The effectiveness of herbicides is determined by the dose so that the dose must be effective in controlling weeds without causing damage to cultivated plants (Dani & Arifin, 2023) [2]. The dose of herbicide applied must be correct, if it is too high it will cause damage or poisoning to cultivated plants, whereas if the dose is too low it will cause the weeds not to die. Based on the explanation above, it is necessary to know the dose of isopropylamine (IPA) glyphosate 245 g/l herbicide which is effective for controlling weeds without causing phytotoxicity to immature coffee plants.

Materials and Methods

The research was conducted from January 2024 to April 2024 at the people's coffee plantation, Tanjung Karya Village, Samarang District, Garut Regency, West Java Province. The experimental location is at an altitude of about ± 1.110 meters above sea level. The average temperature reaches 17-28°C and the average rainfall is 2,589 mm/year.

The tools used in this research include a semi-automatic knapsack sprayer with a T-jet nozzle, measuring cup, bucket, analytical scale, ditch, oven, plastic bag, brown paper envelope, stationery (scissors, ruler, digital caliper, and marker), documentation tool, square measuring 0.5 x

0.5 m, bamboo stakes, and measuring tape. Materials used in this study included the herbicide with the active ingredient IPA Glyphosate 245 g/l, water, coffee plants of the S 795 variety in the immature phase, inorganic fertilizer (NPK 80-100 kg/ha), and organic fertilizer (2,000 kg/ha).
This experiment used the Randomized Group Design (RGD) method with 7 treatments repeated 4 times, resulting in a total of 28 experimental plots. Each experimental plot had a size of 15 m x 2 m. The distance between experimental plots was one row of coffee plants (2.5 m x 2.5 m). The layout of the experimental plots was randomized. The treatments observed that will be carried out in this research is listed in Table 1.

Table 1: Herbicide Treatment with The Active Ingredient IPA Glyphosate 245 g/l

Code	Treatment	Dose (l/ha)
A	IPA Glyphosate 245 g/l	2,25
B	IPA Glyphosate 245 g/l	3,00
C	IPA Glyphosate 245 g/l	3,75
D	IPA Glyphosate 245 g/l	4,50
E	IPA Glyphosate 245 g/l	5,25
F	Weeding Manual	-
G	Control	-

The herbicide application is carried out when the weed cover is at least 75% and is only done once. Spraying uses a semi-automatic knapsack sprayer. This treatment was conducted with the observed weed dry weight and phytotoxicity. Weed dry weight was evaluated at 4, 8, and 12 weeks after application (WAA), while phytotoxicity symptoms were evaluated at 2, 4, 8 weeks after application (WAA). Analysis was carried out using Analysis of Variance (ANOVA) using the F test at 5%. If the treatment shows a real effect, the analysis continues with the Duncan's Multiple Range Test (DMRT) which is used to see the difference in the average value of the treatment at the 95% confidence level.

Results and Discussion

Dry Weight Observation

1. Dry Weight of *Setaria plicata*

Based on the data in Table 2, it shows that various herbicide doses from 2.25 – 5.25 l/ha are effective in controlling *S. plicata* weeds up to 12 WAA. IPA Glyphosate herbicide is translocated to all parts of the weed including the roots. That is the key to controlling *S. plicata* weeds because it can prevent grass weeds from the Poaceae family to reproducing vegetatively. The research conducted by Umiyati *et al.* (2024) [16] states that a glyphosate herbicide is effective in controlling *S. plicata* weeds up to 12 WAA and can replace manual weeding. This is because the application of herbicides will be more labor efficient and save more time (Pujiwati, 2017) [8].

Table 2: Average Dry Weight of *Setaria plicata*

Treatment	Dose (l/ha)	Average Dry Weight of Weeds					
		4 WAA		8 WAA		12 WAA	
A (IPA Glyphosate 245 g/l)	2,25	0,00	a	0,10	a	0,41	a
B (IPA Glyphosate 245 g/l)	3,00	0,00	a	0,07	a	0,41	a
C (IPA Glyphosate 245 g/l)	3,75	0,00	a	0,06	a	0,36	a
D (IPA Glyphosate 245 g/l)	4,50	0,00	a	0,05	a	0,38	a
E (IPA Glyphosate 245 g/l)	5,25	0,00	a	0,09	a	0,33	a
F (Weeding Manual)	-	0,27	a	0,53	ab	3,31	ab
G (Control)	-	1,04	b	1,37	b	6,01	b

Note: WAA = Week After Aplication; Based on Duncan's Multiple Range Test at 5% level, the average treatment value with the same lowercase letter in the same column indicates that the treatment is not significantly different

2. Dry Weight of *Marsypianthes chamaedrys*

The data in Table 3 shows that treatment with the lowest dose (2.25 l/ha) until the highest dose (5,25 l/ha) was able to control *M. chamaedrys* up to 12 WAA. In addition, herbicide treatment can provide better results than manual weeding. According to Sukman & Yakup (1995) [12], broad-leaved weeds have a leaf morphology with an apical meristem system (growing point) that is not protected or not hidden so that it can receive spray and absorb more herbicides. The more herbicide that is absorbed by weeds, the greater the possibility of the herbicide experiencing toxic effects. Therefore, treatment from the smallest to the largest dose can stop the growth and development of the *M. chamaedrys* weed up to 12 WAA.

Table 3: Average Dry Weight of *Marsypianthes chamaedrys*

Treatment	Dose (l/ha)	Average Dry Weight of Weeds					
		4 WAA		8 WAA		12 WAA	
A (IPA Glyphosate 245 g/l)	2,25	0,16	a	0,67	a	2,57	a
B (IPA Glyphosate 245 g/l)	3,00	0,18	a	0,20	a	3,62	a
C (IPA Glyphosate 245 g/l)	3,75	0,03	a	0,14	a	1,38	a
D (IPA Glyphosate 245 g/l)	4,50	0,00	a	0,22	a	1,60	a
E (IPA Glyphosate 245 g/l)	5,25	0,00	a	0,30	a	1,51	a
F (Weeding Manual)	-	1,85	b	3,71	b	11,86	b
G (Control)	-	1,17	b	2,89	b	13,84	b

Note: WAA = Week After Aplication; Based on Duncan's Multiple Range Test at 5% level, the average treatment value with the same lowercase letter in the same column indicates that the treatment is not significantly different

3. Dry Weight of *Drymaria cordata*

Treatment with various doses of the IPA Glyphosate 245 g/l herbicide was effective in controlling *Drymaria cordata* from 4 WAA to 12 WAA (Table 4). Starting from the smallest dose (2.25 l/ha) is able to control *D. cordata*. However, herbicide and manual weeding treatments were

not significantly different, so both treatments showed the same performance.

Weeds can grow back and makes the average dry weight increase. *D. cordata* has the characteristics of being able to adapt and compete highly so that it quickly dominates the land (Kurniadie *et al*., 2016) [5]. Its short life cycle (around 4-6 weeks) causes *D. cordata* to produce seeds in large quantities in a relatively short time (Santosa *et al*., 2009) [10].

Table 4: Average Dry Weight of *Drymaria cordata*

Treatment	Dose (l/ha)	Average Dry Weight of Weeds					
		4 WAA		8 WAA		12 WAA	
A (IPA Glyphosate 245 g/l)	2,25	0,06	a	0,17	a	0,91	a
B (IPA Glyphosate 245 g/l)	3,00	0,00	a	0,12	a	0,77	a
C (IPA Glyphosate 245 g/l)	3,75	0,04	a	0,19	a	0,88	a
D (IPA Glyphosate 245 g/l)	4,50	0,00	a	0,15	a	0,75	a
E (IPA Glyphosate 245 g/l)	5,25	0,00	a	0,09	a	0,73	a
F (Weeding Manual)	-	0,06	a	0,12	a	1,12	ab
G (Control)	-	0,17	b	0,48	b	1,53	b

Note: WAA = Week After Aplication; Based on Duncan's Multiple Range Test at 5% level, the average treatment value with the same lowercase letter in the same column indicates that the treatment is not significantly different

4. Dry Weight of *Artemisia vulgaris*

Table 5 shows that treatment with various herbicide doses was able to suppress the growth of *A. vulgaris* from 4 WAA to 12 WAA. Starting from the smallest dose (2.25 l/ha) is able to control *A. vulgaris* up to 12 WAA. However, Treatments C, D, and E (3.75 – 5.25 l/ha) have quite high doses so that at 12 WAA they show better results than treatments A and B. According to Jatsiyah & Hermanto (2020) [4] the higher the herbicide dose, the smaller the dry weight will be. Supported by the statement of Iskandar & Yudiawati (2022) [3] that the higher the dose of a chemical will cause the ability to control weeds to be greater. The death rate of weeds will be greater due to the effects of phytotoxicity or poisoning on weeds.

Table 5: Average Dry Weight of *Artemisia vulgaris*

Treatment	Dose (l/ha)	Average Dry Weight of Weeds					
		4 WAA		8 WAA		12 WAA	
A (IPA Glyphosate 245 g/l)	2,25	0,18	a	0,26	a	0,67	ab
B (IPA Glyphosate 245 g/l)	3,00	0,16	a	0,19	a	0,63	ab
C (IPA Glyphosate 245 g/l)	3,75	0,14	a	0,16	a	0,41	a
D (IPA Glyphosate 245 g/l)	4,50	0,08	a	0,12	a	0,39	a
E (IPA Glyphosate 245 g/l)	5,25	0,06	a	0,08	a	0,37	a
F (Weeding Manual)	-	0,25	a	0,77	ab	2,87	bc
G (Control)	-	1,27	b	2,30	b	3,06	c

Note: WAA = Week After Application; Based on Duncan's Multiple Range Test at 5% level, the average treatment value with the same lowercase letter in the same column indicates that the treatment is not significantly different

5. Dry Weight of *Galinsoga parviflora*

IPA Glyphosate 245 g/l herbicide from a dose of 2.25 l/ha to 5.25 l/ha can suppress the growth of *G. Parviflora* weeds up to 12 WAA (Table 6). However, it was not significantly different from the manual weeding treatment. This occurred due to an increase in dry weight in weed control treatment plots (herbicides and weeding). According to Wulandari et al. (2014) [19] if weeds that have been controlled by herbicides die, then other weeds will grow at 5 WAA, both from the same weed and other broadleaf weeds. However, weed growth in herbicide treatment plots with various dose levels that have been tested shows that weed growth is more inhibited than manual weeding.

Table 6: Average Dry Weight of *Galinsoga parviflora*

Treatment	Dose (l/ha)	Average Dry Weight of Weeds					
		4 WAA		8 WAA		12 WAA	
A (IPA Glyphosate 245 g/l)	2,25	0,45	a	0,63	ab	1,89	a
B (IPA Glyphosate 245 g/l)	3,00	0,40	a	0,57	ab	1,77	a
C (IPA Glyphosate 245 g/l)	3,75	0,39	a	0,54	ab	1,68	a
D (IPA Glyphosate 245 g/l)	4,50	0,26	a	0,38	ab	1,66	a
E (IPA Glyphosate 245 g/l)	5,25	0,07	a	0,10	a	1,61	a
F (Weeding Manual)	-	0,45	a	2,17	bc	2,33	ab
G (Control)	-	2,51	b	2,10	c	2,80	b

Note: WAA = Week After Application; Based on Duncan's Multiple Range Test at 5% level, the average treatment value with the same lowercase letter in the same column indicates that the treatment is not significantly different

6. Dry Weight of *Ageratum conyzoides*

IPA Glyphosate 245 g/l herbicide treatment can suppress the growth of *A. Conyzoides* from 4 WAA to 12 WAA (Table 7). At 4 and 8 WAA with all dose levels tested was effective in controlling *A. Conyzoides* and has better performance than manual weeding. However, at 12 WAA the manual weeding treatment was not significantly different from the herbicide treatment. However, according to Widaryanto *et al*. (2021) [17] manual weeding cannot kill weeds down to the roots so it will cause the buds to go dormant and the weeds can regrowth quickly.

Table 7: Average Dry Weight of *Ageratum conyzoides*

Treatment	Dose (l/ha)	Average Dry Weight of Weeds					
		4 WAA		8 WAA		12 WAA	
A (IPA Glyphosate 245 g/l)	2,25	0,04	a	0,47	a	1,50	a
B (IPA Glyphosate 245 g/l)	3,00	0,06	a	0,35	a	1,62	a
C (IPA Glyphosate 245 g/l)	3,75	0,06	a	0,28	a	1,58	a
D (IPA Glyphosate 245 g/l)	4,50	0,04	a	0,16	a	1,49	a
E (IPA Glyphosate 245 g/l)	5,25	0,04	a	0,20	a	1,09	a
F (Weeding Manual)	-	0,43	b	1,24	b	2,03	ab
G (Control)	-	0,44	b	1,34	b	2,63	b

Note: WAA = Week After Application; Based on Duncan's Multiple Range Test at 5% level, the average treatment value with the same lowercase letter in the same column indicates that the treatment is not significantly different

Since 4 WAA, glyphosate herbicide treatment has been able to control *A. Conyzoides*. Leaf surface of *A. Conyzoides* is wide and large areas are the key to the effectiveness of herbicide droplets so they can be evenly distributed and absorbed well (Umiyati & Kurniadie, 2018) [14]. According to Widayat *et al*. (2021) [18] after being sprayed by the IPA glyphosate herbicide, *A. Conyzoides* will experience rot starting from the leaves down to the roots.

7. Dry Weight of Other Weeds

Other weeds consist of broadleaf weeds, grasses and sedges. These weeds are *Richardia scabra, Synedrella nodiflora, Mimosa pudica, Borreria alata, Polygala paniculata L., Urena lobata, Bidens pilosa, Cyperus kyllingia, Commelina diffusa, Euphorbia hirta, Cyperus rotundus, Crassocephalum crepidioides, Dichanthelium clandestine, Sida rhombifolia, Digitaria sanguinalis, Oxalis latifolia,* and *Euphorbia heterophylla*. Table 8 shows that treatments of various herbicide doses are effective in controlling other weeds up to 12 WAA. Dry weight results starting from 8 WAA indicate that manual weeding is less effective in controlling other weeds. The reason is because weeds will grow again and supportive environmental factors, such as weed seeds being exposed to sunlight can cause the seeds to germinate (Umiyati & Widayat, 2017) [15]. Apart from that, weeding using a hoe and rake is less effective in controlling weeds which can reproduce vegetatively because it gives the weeds the opportunity to turn the cut parts into shoots to grow again.

Table 8: Average Dry Weight of Other Weeds

Treatment	Dose (l/ha)	Average Dry Weight of Weeds					
		4 WAA		8 WAA		12 WAA	
A (IPA Glyphosate 245 g/l)	2,25	1,55	a	2,93	a	6,67	a
B (IPA Glyphosate 245 g/l)	3,00	1,45	a	2,66	a	6,72	a
C (IPA Glyphosate 245 g/l)	3,75	1,17	a	2,31	a	6,58	a
D (IPA Glyphosate 245 g/l)	4,50	0,49	a	2,08	a	6,22	a
E (IPA Glyphosate 245 g/l)	5,25	0,82	a	2,22	a	5,22	a
F (Weeding Manual)	-	1,79	a	4,54	b	10,52	b
G (Control)	-	3,90	b	6,56	c	10,71	b

Note: WAA = Week After Application; Based on Duncan's Multiple Range Test at 5% level, the average treatment value with the same lowercase letter in the same column indicates that the treatment is not significantly different

8. Dry Weight of Total Weeds

Total weed dry weight is the dry weight of all weed species on the research land. Table 9 shows that herbicide treatment at a dose of 2.25 – 5.25 l/ha is effective in controlling total weeds up to 12 WAA. Total weeds include weeds from the broad-leaf, grass and sedge groups which have a life cycle as annual and perennial weed. This proves that the IPA glyphosate herbicide has a broad control spectrum.

Supported by the statement of Jatsiyah & Hermanto (2020) [4], the IPA glyphosate herbicide can suppress weed growth in total and per group. In fact, it is effective in controlling woody weeds. The success factor is the systemic action of the glyphosate herbicide so that it can damage and kill weed organs both above the ground and in the soil (Zulkipli *et al*., 2016) [20].

Table 9: Average Dry Weight of Total Weeds

Treatment	Dose (l/ha)	Average Dry Weight of Weeds					
		2 WAA		4 WAA		6 WAA	
A (IPA Glyphosate 245 g/l)	2,25	2,44	a	5,23	a	14,61	a
B (IPA Glyphosate 245 g/l)	3,00	2,24	a	4,16	a	15,53	a
C (IPA Glyphosate 245 g/l)	3,75	1,82	a	3,68	a	12,85	a
D (IPA Glyphosate 245 g/l)	4,50	0,86	a	3,15	a	12,47	a
E (IPA Glyphosate 245 g/l)	5,25	0,98	a	3,07	a	10,86	a
F (Weeding Manual)	-	5,09	b	13,07	b	34,04	b
G (Control)	-	10,50	c	17,03	c	40,58	c

Note: WAA = Week After Application; Based on Duncan's Multiple Range Test at 5% level, the average treatment value with the same lowercase letter in the same column indicates that the treatment is not significantly different

Phytotoxicity

Table 10 shows that herbicide applications ranging from doses of 2.25 l/ha to 5.25 l/ha do not cause phytotoxicity in immature coffee plants. At the time of observation there were no visible symptoms of poisoning on the coffee plants so that the results of observations at 2, 4 and 8 WAA had an average phytotoxicity score of zero (0). One of the factors causing no phytotoxicity in immature coffee plants is that the herbicide application method is correct. According to Sigalingging *et al*. (2014) [11] a good and correct way to apply herbicides can prevent the herbicide liquid from getting on the coffee plant parts so that the coffee plants will not experience poisoning due to the herbicide. In addition, the herbicide is applied to the right and left of the coffee plant row to avoid direct contact between the herbicide and the coffee plants.

Table 10: Phytotoxicity of Immature Coffee Plants

Treatment	Dose (l/ha)	Phytotoxicity (%)		
		2 WAA	4 WAA	8 WAA
A (IPA Glyphosate 245 g/l)	2,25	0	0	0
B (IPA Glyphosate 245 g/l)	3,00	0	0	0
C (IPA Glyphosate 245 g/l)	3,75	0	0	0
D (IPA Glyphosate 245 g/l)	4,50	0	0	0
E (IPA Glyphosate 245 g/l)	5,25	0	0	0
F (Weeding Manual)	-	0	0	0
G (Control)	-	0	0	0

Note: WAA = Week After Application; Based on Duncan's Multiple Range Test at 5% level, the average treatment value with the same lowercase letter in the same column indicates that the treatment is not significantly different

Conclusion

In this experiment, various doses of isopropylamine (IPA) glyphosate 245 g/l herbicide proved effective in suppressing weed growth up to 12 WAA. The isopropylamine (IPA) glyphosate 245 g/l herbicide starting from a dose of 2,25 l/ha to 5.25 l/ha is effective in controlling the weeds *Setaria plicata, Marsypianthes chamaedrys, Drymaria cordata, Artemisia vulgaris, Ageratum conyzoides, Galinsoga parviflora*, other weeds, and total weeds up to 12 WAA. The results of the study also showed that the isopropylamine (IPA) glyphosate 245 g/l herbicide at various doses did not cause phytotoxicity in immature arabica coffee plants.

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