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Effectiveness of glyphosate herbicide on suppressing weeds in coffee plantations (plants produce)

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Abstract
Coffee is one of the plantation plants that has high economic value on the world market. This study aims to obtain a recommended dose of herbicide with active ingredients of glyphosate which is effective for controlling weeds in coffee producing plants. The experiment was carried out in the coffee plantation owned by the people, Cidatar Village, Cisurupan Subdistrict, Garut Regency in February to June 2018. Places of type C rainfall (rather wet) according to Schmidt and Fergusson with altitude of 900-1500 meters above sea level. The study used a Randomized Block Design, with 7 (seven) treatments and 4 (four) replications. The treatments tested were the glyphosate dose of 320 gr / ha; 480 gr / ha; 640 gr / ha; 800 gr / ha and 960 gr / ha, as well as manual weeding and without weeding. The results showed that all doses of glyphosate herbicides can suppress the growth of broadleaf weeds and grass weeds. The glyphosate herbicide with a dose of 320 gr / ha was most effective in suppressing the growth of broadleaf weeds and grass weeds.

Keywords: weed, coffee, glyphosate

1. Introduction
Coffee is a commodity that is widely cultivated in Indonesia and has a high economic value on the world market. This plant is one of the mainstay commodities of Indonesian plantations that play a role as the country's foreign exchange earner, source of income for farmers, job creation, encourage agribusiness and agro-industry, and regional development. The volume of Indonesian coffee exports in the last five years experienced fluctuations, namely in 2012 amounted to (448,591 tons), 2013 (534,023 tons), 2014 (384,816 tons), 2015 (502,021 tons), and in 2016 amounted to (267,058 tons) (Direktorat Jenderal Perkebunan, 2006) [2]
The area which is the center of coffee production in Indonesia consists of: Nangroe Aceh Darussalam Province, North Sumatra, East Java, and South Sulawesi. Besides the area there are also other areas which are coffee producers in Indonesia such as West Java Province. Especially for West Java Province, the coffee planting area is in Garut Regency.
Based on data from the Garut Regency Plantation Service in 2016, the level of coffee production in Garut Regency was recorded at 1,729.39 kg per year in 35 sub-districts.
In general, the amount of coffee production in Indonesia has not been as expected, it was caused by several factors, namely: (1) un-certified coffee seedlings, (2) imperfect soil management, (3) improper fertilization, (4) influence weather, and (5) plant pest organisms (OPT), in the form of pests, diseases and weeds. Weed is a confounding plant and detrimental to farmers, these losses can be in the form of decreasing the quantity and quality of results, and can increase production costs (Sembodo, 2010) [9].
Syawal (2010) [11] states that weeds can be associated with cultivated plants and cause interactions, in the form of competition in the struggle for nutrients and sunlight. Shallow rooting results in coffee being unable to compete with weeds in obtaining nutrients. Weeds reduce growth rates and coffee yields by 30% (Zaenudin, 1987) [13]. While according to Widiyanti (2013) [12] the presence of weeds in coffee plantations can reduce seed production to 35%. The types of weeds that often grow and harm coffee plants include *Cynodon dactylon, Digitaria sp., Imperata cylindrica, Cyperus rotundus, Micania cordata, Oxalis corniculata,* and *Salvia* sp. (Najiyati dan Danarti, 2001) [7].
To avoid losses due to the presence of weeds in cultivation crops, weed control efforts need to be carried out. There are several ways to control weeds, namely: (1) in technical culture, (2) mechanically, (3) biologically, and (4) chemically. Weed control is often done by chemically using herbicides. The use of herbicides has several advantages compared to other control techniques. The advantages of using herbicides are: (1) faster suppressing weed growth, (2) more economical, (3) more effective, and (4) saving labor and time (Hadi, 2011) [4].
Herbicides that can be used to control weeds in coffee plants are herbicides with active ingredients paracuat dichloride, sulfosat, glyphosate, ammonium glufosinate, 2,4-D, etc. (Direktorat Jenderal Prasarana dan Sarana Pertanian, 2012) [3]. According to the study Riadi (2011) [8] one type of herbicide that can be used is herbicide with active ingredients glyphosate because it is effective in controlling various types of weeds, including grasses, broadleaf weeds and woody weeds.
Herbicides Glyphosate is systemic in controlling weeds and is a non-selective herbicide that can control various types of weeds. Symptoms of poisoning by glyphosate herbicide namely weed leaves wither, turn yellow, brown, dry out and then die. Metabolism or degradation of glyfosat herbicides in plants is very slow and small, but degradation in soil by microbes is very important (Sriyani, 2012) [10]. To find out the extent of the effectiveness of glyphosate herbicide in suppressing weed growth in coffee plantations, research

needs to be done.

Materials and Methodology

The study was conducted in a coffee plantation owned by the people of Cidatar Village, Cisurupan District, Garut Regency from February to June 2018. Latosol soil types have clay or sandy clay. The altitude of 900-1500 masl with rainfall is included in type C according to Schmidt and Ferguson (1951).

The research materials used were coffee plants (Producing Plants) and 5-year-old Robusta and Arabica species, water, and glyphosate herbicide with concentration of 160 g / l under the trade name PITBULL 160 SL. The tools used include semi-automatic knapsack sprayers and T-jet nozzles with a pressure of 1 kg / cm² (15-20 psi), measuring cups, analytical scales, ovens, hoes, plastic bags, rapia ropes, plastic trays, buckets, meters , bamboo stakes, iron squares measuring 0.5 mx 0.5 m, and stationery.

The research method used was a randomized block design consisting of 7 (seven) treatments and 4 (four) replications, in order to obtain 28 experimental units. The treatment design can be seen in Table 1.

Table 1: Design of Treatment.

No	Treatment	Dose (gram/ha)
A	glyphosate	320
B	glyphosate	480
C	glyphosate	640
D	glyphosate	800
E	glyphosate	960
F	Manual weeding	-
G	Without weeding	-

Data processing is done by various analysis methods. To find out the difference in influence between treatments used the smallest real difference test (LSD) at the real level of 5%.

Responses observed include

1. **Phytotoxicity**

   The number of samples of coffee plants for observing phytotoxicity is as many as three plants in each experimental unit and determined randomly. Then the toxicity or toxicity level was assessed visually on the cultivar population in the treatment plot unit, observed at 2, 4 and 6 weeks after application, observing the level of plant poisoning according to the regulations of the Directorate of Fertilizers and Pesticides, Ministry of Agriculture in the following methods:

   0 = no poisoning, 0–5% leaf shape or leaf color and or coffee plant growth is not normal.

   1 = mild poisoning,> 5–20% leaf shape or leaf color and or abnormal coffee plant growth.

   2 = moderate poisoning,> 20–50% leaf shape or leaf color and or abnormal coffee plant growth.

   3 = severe poisoning,> 50–75% leaf shape or leaf color and or abnormal coffee plant growth.

   4 = very heavy poisoning,> 75% leaf shape or leaf color and or abnormal coffee plant growth.

2. **Weed dry weight**

   The sample data of weed dry weight in each unit of treatment plot was observed in three sample plots (one sample plot of each dish) using the quadratic method measuring 0.5 m x 0.5 m. Then the method of sampling weeds for dry weight data was carried out at 4, 8 and 12 weeks after application. Examples of weeds taken are target weeds, namely weed species found in coffee plantations after the application of glyfosat herbicide. Fresh weeds are cut exactly at the level of the ground, then separated by each type, then the weeds are dried at 80 ° C for 48 hours or until they reach a constant dry weight, then weighed.

Results and Discussion

Phytotoxicity

The results of observations of phytotoxicity or toxicity of herbicides on coffee plants conducted with observation intervals of 2, 4 and 6 MSA (weeks after application) showed that all treatments of glyfosat herbicide did not cause phytotoxicity in coffee plants (Scale 0). This can be seen based on visual observations, namely the absence of damaged plants both roots, stems, leaves and fruit. This means that the growth of coffee plants grows normally, and there is no change in color (chlorosis) as well as weeds affected by the herbicide glyphosate.

Weed dry weight

Ageratum conyzoides

The effect of glyphosate herbicide on the average dry weight of *Ageratum conyzoides* weeds in observations 4, 8, and 12 week after application can be seen in Table 2. *Ageratum conyzoides* weeds are the most dominant type of broad-leaf weed found in coffee plants (Plants Produce).

Table 2: Average Dry Weight of *Ageratum conyzoides* Weeds

Treatment	Weed dry weight (g)		
	4 week after application	8 week after application	12 week after application
A (Glyphosate 320 g/ha)	0 a	0 a	0 a
B (Glyphosate 480 g/ha)	0 a	0 a	0 a
C (Glyphosate 640 g/ha)	0 a	0 a	0 a
D (Glyphosate 800 g//ha)	0 a	0 a	0 a
E (Glyphosate 960 g/ha)	0 a	0 a	0 a
F (Manual weeding)	0,46 a	1,02 b	1,43 b
G (Without weeding)	3,82 b	6,03 c	7,15 c

Description: Numbers accompanied by different letters in the same column show significantly different from the 5% LSD test.

Based on Table 2, it can be seen at 4, 8, and 12 week after application, all treatments of the dose of glyphosate herbicide (Treatment A, B, C, D, and E) effectively suppressed the growth of *Ageratum conyzoides* weeds. The 5% LSD test results showed that all treatments of glyphosate herbicide dose showed a significantly different average number compared to treatment F (manual weeding) and G (without weeding) in suppressing the growth of

weeds of *Ageratum conyzoides* but between treatment doses were not significantly different. This is in accordance with the opinion Riadi (2011) [8] which states that glyphosate herbicide is effective in controlling various weeds including broadleaf weeds.

Borerria alata

The results of the experimental observations on the average number of weed dry weight in the observations 4, 8 and 12 week after application can be seen in Table 3. *Borerria alata* weeds belong to the second dominant group of broad-leafed weeds found in coffee-producing plants.

Table 3: Dry weeds weights *Bataria alata*

Treatment	Weed dry weight (g)		
	4 week after application	8 week after application	12 week after application
A (Glyphosate 320 g/ha)	0 a	0 a	0 a
B (Glyphosate 480 g/ha)	0 a	0 a	0 a
C (Glyphosate 640 g/ha)	0 a	0 a	0 a
D (Glyphosate 800 g//ha)	0 a	0 a	0 a
E (Glyphosate 960 g/ha)	0 a	0 a	0 a
F (Manual weeding)	0 a	0.33 a	1.25 b
G (Without weeding)	4.49 b	6.4 b	9.07 c

Description: Numbers accompanied by different letters in the same column show significantly different from the 5% LSD test.

Based on Table 3 it can be seen in observations 4, 8 and 12 week after application, all treatments of the dose of herbicide glyphosate effectively suppressed weed growth *Borerria alata*. This is based on the results of the analysis that all doses of glyphosate herbicide (Treatment A, B, C, D, and E) at 4, 8, and 12 week after application show the average number that is significantly different from treatment F (manual weeding) and G (without weeding) in suppressing weed growth *Bataria alata* but between doses of treatment are not significantly different.

Paspalum conjugatum

The experimental results of the average weed dry weight *Paspalum conjugatum* on observations 4, 8, and 12 week after application can be seen in Table 4. *Paspalum conjugatum* belongs to the third dominant group of weed weeds found in coffee producing plants.

Based on Table 4, it can be seen that in observations 4, 8 and 12 week after application, all treatments of the dose of glyphosate herbicide effectively suppressed weed growth in *Paspalum conjugatum*. This is based on the results of statistical analysis that the average number of weed dry weight of all treatments of Glifosay herbicides were significantly different from treatment G (without weeding) but not significantly different from treatment F (Weeding manually). Systemic glyphosate herbicides are very effective in controlling grass weeds. Systemic herbicide toxins will enter plant tissues and are translocated, so systemic herbicides are very effective for controlling weeds that have rhizome or stolone (Hill, 1997) [5].

Tabel 4: Dry weeds weights *Paspalum conjugatum*

Treatment	Dry weeds weights (g)		
	4 week after application	8 week after application	12 week after application
A (Glyphosate 320 g/ha)	0 a	0.92 b	0.08 a
B (Glyphosate 480 g/ha)	0 a	0.08 a	0 a
C (Glyphosate 640 g/ha)	0 a	0 a	0 a
D (Glyphosate 800 g//ha)	0 a	0 a	0 a
E (Glyphosate 960 g/ha)	0 a	0 a	0 a
F (Manual weeding)	0 a	0.15 a	0.75 b
G (Without weeding)	1.73 b	5.52 c	6.86 c

Description: Numbers accompanied by different letters in the same column show significantly different from the 5% LSD test.

Axonopus compressus

The experimental results of the average weed dry weight of *Axonopus compressus* at observations 4, 8 and 12 week after application can be seen in Table 5. *Axonopus compressus* weeds are the fourth dominant type of weed grass after *Ageratum conyzoides*, *Borerria alata* and *Paspalum conjugatum* found in coffee plants produces

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Table 5: Average weed dry weight *Axonopus compressus*

Treatment	Dry weeds weights (g)		
	4 week after application	8 week after application	12 week after application
A (Glyphosate 320 g/ha)	0.06 ab	0 a	0 a
B (Glyphosate 480 g/ha)	0.03 a	0 a	0 a
C (Glyphosate 640 g/ha)	0 a	0 a	0 a
D (Glyphosate 800 g//ha)	0 a	0 a	0 a
E (Glyphosate 960 g/ha)	0 a	0 a	0 a
F (Manual weeding)	0.12 a	0.30 a	1.22 b
G (Without weeding)	2.4 b	3.40 b	4.53 c

Description: Numbers accompanied by different letters in the same column show significantly different from the 5% LSD test.

Based on Table 5, it can be seen that in observations 4, 8 and 12 week after application, all treatments of the dose of

glyphosate herbicide effectively suppressed weed growth in Axonopus compressus.. This is based on statistical analysis that shows the average number of weed dry weight of all glyfosat herbicide treatments that were significantly different from treatment G (without weeding) but not significantly different from treatment F (Manual weeding).

***Clidemia hirta*.**

The results of experimental observations on the average dry weed weight of *Clidemia hirta* in the observations 4, 8 and 12 week after application can be seen in Table 6. *Clidemia hirta* is the fifth dominant broadleaf weed after *Ageratum conyzoides, Borerria alata, Paspalum conjugatum* and *Axonopus compressus* is found in produce coffee plants.

Table 6: Average weed dry weight *Clidemia hirta*

Treatment	Dry weeds weights (g)		
	4 week after application	8 week after application	12 week after application
A (Glyphosate 320 g/ha)	0 a	0 a	0 a
B (Glyphosate 480 g/ha)	0 a	0 a	0 a
C (Glyphosate 640 g/ha)	0 a	0 a	0 a
D (Glyphosate 800 g//ha)	0 a	0 a	0 a
E (Glyphosate 960 g/ha)	0 a	0 a	0 a
F (Manual weeding)	0 a	0.17 b	0.77 a
G (Without weeding)	1.73 b	3.12 c	2.70 b

Description: Numbers accompanied by different letters in the same column show significantly different from the 5% LSD test.

Based on Table 6 it can be seen that in observations 4, 8 and 12 week after application, all treatments of the dose of glyphosate herbicide effectively suppress weed growth *Clidemia hirta*.. This is based on statistical analysis that shows the average number of weed dry weight of all glyfosat herbicide treatments that were significantly different from treatment G (without weeding) but not significantly different from treatment F (Manual weeding).

Tetracera indica

The results of the experimental observations on the average dry weed weight of *Tetracera indica* in observations 4, 8 and 12 week after application can be seen in Table 7. *Tetracera indica* is a type of broadleaf weed which is the sixth dominant after *Ageratum conyzoides, Borerria alata, Paspalum conjugatum, Axonopus compressus* and *Clidema hirta* are found in coffee plants.

Table 7: Average dry weight *Tetracera indica*

Treatment	Average dry weight (g)		
	4 week after application	8 week after application	12 week after application
A (Glyphosate 320 g/ha)	0 a	0 a	0 a
B (Glyphosate 480 g/ha)	0 a	0 a	0 a
C (Glyphosate 640 g/ha)	0 a	0 a	0 a
D (Glyphosate 800 g//ha)	0 a	0 a	0 a
E (Glyphosate 960 g/ha)	0.44 a	0 a	0 a
F (Manual weeding)	0.55 a	0.06 a	0.29 a
G (Without weeding)	1.12 b	2.38 b	3.45 b

Description: Numbers accompanied by different letters in the same column show significantly different from the 5% LSD test.

Based on Table 7, it can be seen that in observations 4, 8 and 12 week after application, all treatments of the dose of herbicide glyphosate effectively suppressed the growth of weeds *Tetracera indica*.. This is based on statistical analysis that shows the average number of weed dry weight of all glyfosat herbicide treatments that were significantly different from treatment G (without weeding) but not significantly different from treatment F (Manual weeding).

Other weed dry weight

The results of experimental observations of the average number of other weeds dry weight at observations 4, 8, and 12 week after application can be seen in Table 8.

Table 8: Average other dry weed weight

Treatment	Average dry weight (g)		
	4 week after application	8 week after application	12 week after application
A (Glyphosate 320 g/ha)	0.63 a	1.11 ab	0.84 a
B (Glyphosate 480 g/ha)	0.59 a	0.03 a	0.05 a
C (Glyphosate 640 g/ha)	0.31 a	0.06 a	0.09 a
D (Glyphosate 800 g//ha)	0 a	0.03 a	0.02 a
E (Glyphosate 960 g/ha)	0 a	0 a	0.03 a
F (Manual weeding)	1.18 a	2.22 b	4.12 b
G (Without weeding)	7 b	7 c	10.89 c

Description: Numbers accompanied by different letters in the same column show significantly different from the 5% LSD test.

Based on Table 8, it can be seen that in observations 4, 8 and 12 week after application, all treatments of the dose of glyphosate herbicide effectively suppressed the growth of other weeds. This is based on statistical analysis that shows the average number of weed dry weight of all glyfosat herbicide treatments that were significantly different from treatment G (without weeding) and treatment F (manual weeding).

Total weed dry weight

Total weed dry weight was the dry weight of all types of weeds found at the time of observation, the dry weight of total weeds showed the level of weed population in an experimental plot. The results of analysis of total weed dry weight are presented in Table 9.

Based on Table 9 it can be seen that in observations 4, 8 and 12 week after application, all treatments of the dose of glyphosate herbicide effectively suppressed total weed growth.. This is based on statistical analysis that shows the average number of weed dry weight of all glyfosat herbicide treatments that were significantly different from treatment G (without weeding) and treatment F (manual weeding). This indicates that glyphosate herbicide has been translocated to all parts of the weeds, especially the roots which can cause the weed death more effectively (Johal and Huber, 2009).

If the plant's dry weight remains or decreases, it can be assumed that there is a disruption in the plant's metabolic processes. The disturbance is caused by the glyphosate herbicide is well absorbed by the weeds and then translocated to all young plant tissues and actively dividing through phloem. Effects that occur from the leaves to roots cause the growth process to be very slow so the control rotation can take longer (Riadi, 2011) [8].

Table 9: Average total weed dry weight

Treatment	Average dry weight (g)		
	4 week after application	8 week after application	12 week after application
A (Glyphosate 320 g/ha)	1.99 a	2.03 ab	0.93 a
B (Glyphosate 480 g/ha)	1.38 a	0.12 a	0.06 a
C (Glyphosate 640 g/ha)	0.81 a	0.06 a	0.10 a
D (Glyphosate 800 g//ha)	0.14 a	0.04 a	0.03 a
E (Glyphosate 960 g/ha)	0.12 a	0.00 a	0.04 a
F (Manual weeding)	1.85 a	4.27 b	9.87 b
G (Without weeding)	24.66 b	33.88 c	45.16 c

Description: Numbers accompanied by different letters in the same column show significantly different from the 5% LSD test.

According to Ariyani dan Junaedi (2007) [1] glyfosat is an active, non-selective herbicide, absorbed through leaves and translocated to growing regions, is effective in eradicating annual and chronic weeds but is more intended to eradicate chronic weeds that have deep roots, especially grasses rooted by rhizome. This herbicide is systemic and not selective with a working mechanism affecting the synthesis of essential amino acids. Glyphosate herbicides can affect the pigment until chlorosis occurs, growth stops and plants can die. This herbicide also inhibits the biosynthetic path of aromatic amino acids.

Conclusion

Based on the results of the study, conclusions can be drawn:

1. All doses of glyphosate herbicide, can suppress the growth of broadleaf weeds and grass weeds.
2. Glyphosate herbicide dose of 320 grams / ha is most effective in suppressing the growth of broadleaf weeds and grass weeds.

Application of research: The presence of weeds in coffee plantations can reduce coffee production, so the presence of weeds must be controlled. One of the most effective and efficient ways to control weeds is by using glyphosate herbicide.

Abbreviations

g = gram
ha = hectare
LSD = Least Significant Differences

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