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Effects of metsulfuron methyl herbicide doses on weed suppression, growth and yield of rice (*Oryza sativa* L.)

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Abstract
One of the factors to production of the rice paddy is the environment the existence of weeds which growth and yield of rice paddy. Weed control using the chemical method of using herbicides is more effective than other weed controls. This research aims to review the efficacy of Metsulfuron Methyl herbicide the growth and yield of rice (*Oryza sativa* L.). This research was conducted in Desember 2018 – April 2019 in SPLPP (Sanggar Penelitian Latihan dan Pengembangan Pertanian), Baleendah District, Bandung Regency, West Java. This design used was a Randomized Block Design with 7 treatments and 4 replications. The type of treatment in this research consited of : Metsulfuron Methyl herbicide at a dose of 10g/ha, Metsulfuron Methyl herbicide at a dose of 15g/ha, Metsulfuron Methyl herbicide at a dose of 20g/ha, Metsulfuron Methyl herbicide at a dose of 25g/ha, Metsulfuron Methyl herbicide at a dose of 30g/ha, weeding 3 and 5 MST, control (without weeding and without herbicides). The difference between treatments was tested using the Duncan test at real level of 5 %. The result showed that Metsulfuron Methyl herbicide at a dose of 20 g/ha were able to *Ludwigia perennis*, *Fimbristylis miliacea*, *Limnocharis flava*, *Leersia hexandra* and *Monochoria vaginalis* can control weeds and influence the growth and yield of rice plants.

Keywords: metsulfuron methyl, weeds, herbicide, rice

Introduction
Food plants are a group of plants that source carbohydrates and protein. One of the plants of this type of food is rice. Rice commodity is one of the most widely grown food plants in Indonesia, because rice produces rice which is a staple food and is highly needed by Indonesian people (Naibaho, 2011) [5].
Rice production is influenced by several factors, one of which is maintenance such as weed control. Weed is a type of plant that can reduce rice productivity. The presence of weeds in plants can lead to competition and competition for nutrients, water, light, CO2, and growing space. The level of competition between weeds and plants depends on environmental conditions, crop varieties, weed density, how long the plants grow with weeds, and the age of the plants when weeds begin to compete (Jatmiko *et al.*, 2002) [1].
Weed control can be done with chemical control so that it can suppress or even kill weeds (Moenandir, 1993). The reason farmers use herbicides is because of the lack of labor in weeding and the high cost of labor. This causes farmers who used to control weeds mechanically to start switching by using chemical control by using herbicides (Pane *et al*., 1999) [6]. Chemical control is felt to have a better advantage compared to other methods, both in terms of cost and labor (Sembodo, 2010) [9].
One type of herbicide that can be used is methylphurone which is a systemic active ingredient. Methulfuron methyl herbicide is a herbicide belonging to the Sulfonylurea family which works by inhibiting the action of the enzymes acetolactate synthase (ALS) and acetohydroxy synthase (AHAS) (Senseman, 2007) [10]. Tomlin (2009) [13] states that the initial mechanism of this herbicide works by inhibiting the change in α ketoglutarate to 2-acetohydroxybutyrate and pyruvate to 2-acetolactate, resulting in the amino acid branch chain valine, leucine, and isoleucine are not produced. The effectiveness of administration of herbicides is determined by the dose. The right dose of herbicide can kill the target weed, but if the dose is too high it will damage the cultivation plants (Sembodo, 2010) [9].
Based on Rahayu's research (2002) that the effectiveness of weed control with methyluride methyl herbicide dose of 20g / ha - 30g / ha mixed with 2.4 D herbicide is very good for controlling Monocharia vaginalis weed. Furthermore, in the research of Koriyando, *et al*. (2014) concluded that the methulfuron methyl herbicide dose 15.75 - 31.50 g / ha effectively controlled the growth of total weeds at 4, 6, 8, and 12 weeks after application. The herbicide Mety lmetsulfuron dose 15.75 to 31.50 g / ha is effective in controlling weed *Ageratum conyzoides and Synedrella nodiflora, Axonopus compressus,* and *Cyperus kyllingia*. The methylphuron methyl herbicide causes a change in weed communities in the oil palm plant disc.

Material and Method
This research was conducted at SPLPP (Sanggar Penelitian Latihan dan Pengembangan Pertanian) Ciparay, Baleendah District, Bandung Regency, West Java Province. The time of this research starts from December 2018 - April 2019.
The tools used in this research are Semi-automatic Knapsack Sprayer for spraying herbicides, weed survay devices, measuring cups to measure the volume of herbicides to be used, ovens used to remove water from plant biomass, analytical scales to calculate the total dry weight of plant biomass, meters for measure plant height, and camera. The materials used are Ciherang cultivar rice

seeds, basic fertilizers namely Urea, SP-36 and KCl, Trendy 20 WP Herbicide made from metsulfuron methyl.
The research method used was an experimental method with a randomized block design consisting of 7 treatments each repeated 4 times. The full treatment is presented in Table 1.

Table 1: Research Treatment

No.	Treatment	Dose (g/ha)
A	Metsulfuron methyl	10
B	Metsulfuron methyl	15
C	Metsulfuron methyl	20
D	Metsulfuron methyl	25
E	Metsulfuron methyl	30
F	Manual weeding	-
G.	Control (without weeding)	-

Data processing is done by using various analysis methods. To determine the difference in effect between treatments used Duncan's test at a 95% confidence level.

Response plan
1. Weed Dry Weights
Weed sampling was carried out on each unit of treatment plot, two squares of 0.5 m x 0.5 m were observed. the location of quadratic plots is systematically determined. Weed collection for biomass data and total weeds was carried out at 3 and 6 weeks after application. Examples of weeds taken are all the target weeds that grow in the treatment plot. Fresh weeds are cut right up to the ground level, then separated by each species. Furthermore, the weeds are dried at 80^0C for 48 hours or until they reach a constant dry weight, then weighed.
2. Rice Plant Height
Rice plant height is measured by measuring the length from the base of the stem to the tip of the longest leaf. Samples taken were 10 clusters per plot. Rice height measurements were carried out 2 times, namely when the rice plants were 3 and 6 weeks after application.
3. Phytotoxicity of Rice Plants
The level of poisoning was assessed visually against the population of rice plants in the tiled plots, observed at 1, 2 and 3 weeks after application. Poisoning scoring as follows:
0 = no poisoning, 0 - 5% leaf shape or leaf color and / or abnormal plant growth.
1 = Mild poisoning,> 5 - 20% leaf shape or leaf color and or abnormal plant growth.
2 = Medium poisoning,> 20 - 50% leaf shape or leaf color and or abnormal plant growth.
3 = Severe poisoning,> 50 - 75% of leaf shape or leaf color and / or abnormal plant growth.
4 = Poisoning is very heavy,> 75% of leaf shape or leaf color and / or abnormal plant growth until the plant dies.
4, Dry milled grain weight
Observation of the weight of the milled unhusked rice was carried out on each plot of experiments, which was carried out by weighing the results of the unhulled grain with the help of sunlight.

Results and Discussion
Weed Dry Weight
1. Weed *Ludwigia perennis*
The experimental results show that the application of methulfuron methyl herbicide dose of 10 g / ha up to 30 g / ha can control weed Ludwigia perennis until observation 6 weeks after the application is shown with a significantly lower weed biomass dry weight compared to manual weed control and control (Table 2).
At 6 weeks after application there was a noticeable difference between the treatment given the herbicide Metylmetsulfuron and the control. The highest weed biomass was in the control treatment with a value of 13.51 grams, while for the lowest biomass was in the treatments B and C with values of 3.81 and 0.52. This shows that the administration of herbicide made from metsulfuron methyl is able to control *Ludwigia perennis* weeds in paddy fields (Table 2). This is in line with the opinion of Shing et. al. (2015) that methulfuron methyl herbicide is very effective in controlling broadleaf weeds in cultivation crops because methulfuron methyl is a systemic herbicide and can inhibit the formation of amino acids.

Table 2: Effect of the application of methulfuron methyl herbicide on dry weights of *Ludwigia perennis* weed (g / 0.25 m²)

	Treaments	Dose (g/ha)	Weed Dry Weights	
			3 weeks after application	6 weeks after application
A	Metsulfuron methyl	10	0.99 ab	3.96 b
B	Metsulfuron methyl	15	1.91 bc	3.81 b
C	Metsulfuron methyl	20	0.59 ab	0.52 a
D	Metsulfuron methyl	25	0.90 ab	0.00 a
E	Metsulfuron methyl	30	0.36 a	0.00 a
F	Manual weeding	-	1.17 ab	1.38 ab
G	Control (without weeding)	-	3.48 c	13.51 c

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.
2. Weed *Monochoria vaginalis*
Monochoria vaginalis weed is a broad leaf group of weeds that grow quite a lot on the land at the test site. Monochoria vaginalis weed is a type of annual weed that has straight and round stems and can multiply by using its seeds. The danger of broadleaf weeds in cropping is better able to reduce crop yields when compared to grass weeds or the like (Sastroutomo, 1990) [8].

Table 3: Effect of the application of methulfuron methyl herbicides on dry weights of *Monochoria vaginalis* (g / 0.25 m²).

	Treaments	Dose (g/ha)	Weed Dry Weights	
			3 weeks after application	6 weeks after application
A	Metsulfuron methyl	10	1.21 bc	3.12 bc
B	Metsulfuron methyl	15	1.71 c	2.43 abc
C	Metsulfuron methyl	20	0.15 a	0.54 a
D	Metsulfuron methyl	25	0.39 ab	0.93 a
E	Metsulfuron methyl	30	0.00 a	0.49 a
F	Manual weeding	-	0.99 bc	1.59 abc
G	Control (without weeding)	-	1.73 c	3.93 c

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

Table 3 shows that from 3 weeks after the application of the methyluride methyl herbicide dose of 20-30 g / ha had an influence on the dry weight of *Monochoria vaginalis* weed at observations 3 and 6 weeks after application. These conditions indicate that methulfuron methyl herbicide is effective in controlling annual broadleaved weeds.

3. Weed *Leersia hexandra*

The results of observations and data analysis showed that the application of methulfuron methyl herbicide starting at 20 g / ha gave a lower dry weight of the *Leersia hexandra* weed compared to the control treatment and was relatively the same as the manual weeding treatment at observation 3 to 6 weeks after application (Table 4). This fact indicates that the application of metsulfuron methyl herbicide at a dose of 20 g / ha has been effective for controlling *Leersia hexandra* weeds in lowland rice cultivation until observations 6 weeks after application (Table 4). In line with the opinion of Wang *et. al.* (2008) [14] that methyl methulfuron herbicide was effective in controlling broadleaved weeds in cereal plants.

Table 4: Effect of the application of methulfuron methyl herbicides on dry weights of *Leersia hexandra* weed (g / 0.25 m²)

	Treaments	Dose (g/ha)	Weed Dry Weights	
			3 weeks after application	6 weeks after application
A	Metsulfuron methyl	10	1.48 b	3.68 c
B	Metsulfuron methyl	15	1.30 b	2.61 bc
C	Metsulfuron methyl	20	0.22 a	0.62 a
D	Metsulfuron methyl	25	0.23 a	0.41 a
E	Metsulfuron methyl	30	0.00 a	0.44 a
F	Manual weeding	-	0.75 ab	1.46 ab
G	Control (without weeding)	-	1.83 b	4.19 c

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

4. Weed *Fimbristylis miliacea*

Fimbristylis miliacea is a group of puzzle weeds that grow on the trial site. Observations 6 weeks after application showed that the application of methulfuron methyl herbicide starting at a dose of 20 g / ha could control weed Fimbristylis miliacea as indicated by the weed biomass dry weight which was significantly lower and significantly different than the control treatment, but not significantly different from weed control manually (Table 5). This can be interpreted that the application of methulfuron methyl herbicide from a dose of 20 g / ha has been effective for controlling weed *Fimbristylis miliacea* up to 6 weeks after application. This is because methyl methulfuron is systemic, absorbed by roots and leaves, and is transplanted acropetally and basipetal. Sensitive weeds will stop growing almost immediately after application and will die within 7-21 days (Djojosumarto, 2008).

Table 5: Effect of the application of methulfuron methyl herbicides on dry weights of *Fimbristylis miliacea* (g / 0.25 m²)

	Treaments	Dose (g/ha)	Weed Dry Weights	
			3 weeks after application	6 weeks after application
A	Metsulfuron methyl	10	1.82 b	3.96 c
B	Metsulfuron methyl	15	0.56 a	1.11 ab
C	Metsulfuron methyl	20	0.00 a	0.13 a
D	Metsulfuron methyl	25	0.00 a	0.00 a

E	Metsulfuron methyl	30	0.00 a	0.00 a
F	Manual weeding	-	0.32 a	0.56 a
G	Control (without weeding)	-	0.50 a	3.00 bc

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

5. Weed Limnocharis *flava*

Limnocharis flava weed is a type of broadleaf weed that is easy to grow in areas that are slightly moist and somewhat protected. Observation results at 6 weeks after application showed that the application of methulfuron methyl herbicide starting at a dose of 15 g / ha could control Limnocharis flava weeds, which was indicated by the weed biomass dry weight which was significantly lower and significantly different than the control treatment, but not significantly different from weed control manual (Table 6). This can be interpreted that the application of methulfuron methyl herbicide dose of 15 g / ha has been effective for controlling *Limnocharis flava* weeds. In line with the opinion of Sondhia (2009) [12] that methulfuron methyl herbicide is very effective in controlling broadleaved weeds.

Table 6: Effects of the application of methulfuron methyl herbicides on dry weights of *Limnocharis flava* (g / 0.25 m²)

Treaments		Dose (g/ha)	Weed Dry Weights	
			3 weeks after application	6 weeks after application
A	Metsulfuron methyl	10	1.35 a	1.81 bc
B	Metsulfuron methyl	15	0.37 a	0.74 ab
C	Metsulfuron methyl	20	0.55 a	0.97 ab
D	Metsulfuron methyl	25	0.36 a	0.00 a
E	Metsulfuron methyl	30	0.19 a	0.16 a
F	Manual weeding	-	0.79 a	1.09 abc
G	Control (without weeding)	-	1.31 a	2.30 c

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

6. Other Weed Species

Dried weights of other species are the dry weights of several weed species (not including the dominant species) that were found at the time of observation in the observed quadratic plots. Other species of weeds include weeds *Marsilea crenata, Echinochloa colona, Cyperus difformis, Cyperus iria and Sphenoclea zeylanica*. The results of observations and analysis showed that the application of methulfuron methyl herbicide from a dose of 20 g / ha suppressed the weed dry weight of other species at 3 and 6 weeks after application indicated by the weed biomass dry weight that was significantly lower and significantly different from manual weed control and control (Table 7). This can be interpreted that the application of methulfuron methyl herbicide starting at a dose of 20 g / ha is effective for controlling weeds of other species in lowland rice cultivation until 6 weeks after application.

Table 7: Effect of the application of methulfuron methyl herbicides on dry weights of other species of weed (g / 0.25 m²)

Treaments		Dose (g/ha)	Weed Dry Weights	
			3 weeks after application	6 weeks after application
A	Metsulfuron methyl	10	2.73 b	5.99 bc
B	Metsulfuron methyl	15	2.08 b	4.17 b
C	Metsulfuron methyl	20	0.41 a	0.74 a
D	Metsulfuron methyl	25	0.11 a	0.55 a
E	Metsulfuron methyl	30	0.00 a	0.53 a
F	Manual weeding	-	1.96 b	3.52 b
G	Control (without weeding)	-	2.75 b	7.75 c

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

7. Total Weed

Total weed dry weights are calculated from the total weed dry weights at the test site. The results of the experiment showed that the application of methulfuron methyl herbicide from a dose of 20 g/ha could reduce the total weed weight indicated by the weed biomass dry weight which was significantly lower and significantly different from manual weed control and control until observation 6 weeks after application (Table 8). These results indicate that the application of the methyl methyl methyl herbicide is effective for controlling total weeds starting at a dose of 20 g/ha in lowland rice cultivation up to 6 weeks after application. According to Marble *et. al.* (2016) [4] that the use of methyl herbicides effectively controls broadleaved weeds and some grass weeds.

Table 8: Effect of the application of methulfuron methyl herbicide on total weed dry weights (g / 0.25 m²)

Treaments		Dose (g/ha)	Weed Dry Weights	
			3 weeks after application	6 weeks after application
A	Metsulfuron methyl	10	9.57 de	22,. 2 e
B	Metsulfuron methyl	15	7.93 d	14.86 d
C	Metsulfuron methyl	20	1.92 b	3.52 b
D	Metsulfuron methyl	25	1.98 b	1.89 a
E	Metsulfuron methyl	30	0.54 a	1.62 a
F	Manual weeding	-	5.89 c	10.60 c
G	Control (without weeding)	-	11.60 e	33.84 f

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

Rice plant height

The results of the analysis due to the treatment of rice plant height are presented in Table 9. From the data in the table it can be seen that all metsulfuron methyl herbicide treatments did not show the average number of plant heights that were no different from the control treatments observed 3 and 6 weeks after application. This is consistent with the opinion of Suprihatno (2010) that the height of the stems of plants is influenced by the traits or characteristics

that affect the yield capacity of varieties.

Table 9: Effect of Metsulfuron Methyl Herbicide Application on Rice Plant Height

No	Treaments	Dose (g/ha)	Plant height (cm)	
			3 weeks after application	6 weeks after application
A	Metsulfuron methyl	10	60.18 a	66.86 a
B	Metsulfuron methyl	15	62.24 a	70.73 a
C	Metsulfuron methyl	20	63.63 a	72.46 a
D	Metsulfuron methyl	25	59.97 a	70.09 a
E	Metsulfuron methyl	30	61.26 a	70.04 a
F	Manual weeding	-	60.77 a	68.79 a
G	Control (without weeding)	-	61.10 a	68.53 a

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

Number of Vegetative Tiller per Clump

The number of tillers is one component of rice plant growth that can be observed to see the response of plant growth to treatments other than plant height. Rice tillers are an indicator of rice growth that shows healthy or sick plants (Makarim and Suhartatik, 2008). Observations at 3 weeks after application of the number of tillers per family showed that the treatment of the methulfuron methyl herbicide starting at a dose of 10 g/ha was not significantly different from the manual weeding and control treatments (Table 10). At 6 weeks after application the number of tillers produced by the control was the least and significantly different from the methylphurone methyl dose of 15 to 30 g/ha and the manual weeding treatment, but not different from the dose of Metylmetsulfuron dose of 10 g/ha. This situation shows that the treatment of methulfuron methyl herbicide from a dose of 15 g/ha can increase the number of tillers in the observation 6 weeks after application. According Husna (2010), the number of tillers will be maximal if the plant besides having good genetic traits is also added to favorable environmental conditions or in accordance with plant growth and development.

Table 10: Effect of the application of metsulfuron methyl herbicide on the number of tillers of rice plants

No	Treaments	Dose (g/ha)	Number of tillers of rice plants	
			3 weeks after application	6 weeks after application
A	Metsulfuron methyl	10	23.86 a	30.94 a
B	Metsulfuron methyl	15	23.54 a	33.23 bc
C	Metsulfuron methyl	20	23.17 a	32.92 b
D	Metsulfuron methyl	25	25.17 a	35.25 c
E	Metsulfuron methyl	30	24.13 a	34.25 bc
F	Manual weeding	-	22.73 a	34.81 bc
G	Control (without weeding)	-	24.71 a	30.79 a

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

Phytotoxicity of Rice Plants

The results of observations of phytoxicity in rice plants showed that the application of methulfuron methyl herbicide from 10 g / ha did not cause poisoning symptoms in rice plants until observations 1-3 weeks after application (Table 11).

Table 11: Toxicity Rate of Rice Plants Due to the Treatment of methulfuron methyl Herbicide

Treaments		Dose (g/ha)	Toxicity Rate		
			1 weeks after application	2 weeks after application	3 weeks after application
A	Metsulfuron methyl	10	0	0	0
B	Metsulfuron methyl	15	0	0	0
C	Metsulfuron methyl	20	0	0	0
D	Metsulfuron methyl	25	0	0	0
E	Metsulfuron methyl	30	0	0	0

According to Soerjandono (2005), persistence is the length of biological activity of herbicides in the soil which is a result of absorption, washing, and biological or nonbiological degradation. Herbicides with low persistence are good to use because the biological activity of herbicides can work quickly, so that herbicides that are absorbed by plants are low. According to Fageria *et al*. (2008), symptoms of poisoning can be seen at each stage of plant growth (vegetative and generative). Plant poisoning due to herbicides can be influenced by several factors including active ingredients of the herbicide used, the environment, and application techniques. Inappropriate application of herbicides can cause death in rice plants.

Rice Grain Dry Rice

The results of the analysis of rice crop yields due to treatment can be seen in Table 12. In Table 12 it can be seen that the treatment of the methulfuron methyl herbicide dosage of 15 g / ha to 30 g / ha gives a higher and significantly different rice grain yield of rice. with control treatment, but not significantly different compared to weeding treatment manually. These results indicate that the application of methulfuron methyl herbicide starting at a dose of 15 g / ha can increase rice yields.

Table 12: Effect of the application of methulfuron methyl herbicide on dry rice milled

No	Treaments	Dose (g/ha)	Rice Grain Dry Rice (g/m^2)
A	Metsulfuron methyl	10	2036.25 a
B	Metsulfuron methyl	15	2153.50 bc
C	Metsulfuron methyl	20	2610.00 c
D	Metsulfuron methyl	25	2695.25 c
E	Metsulfuron methyl	30	2567.50 bc
F	Manual weeding	-	2771.00 c
G	Control (without weeding)	-	2078.25 a

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

Conclusion

Based on the results of experiments conducted in this study, it can be concluded that:

1. Herbicide containing methulfuron methyl active ingredients effectively control the growth of weed Ludwigia perennis, Fimbristylis miliacea, Limnocharis flava starting, Leersia hexandra, Monochoria vaginalis, weeds of other species and total weeds until observation 6 weeks after application at a dose of 20 g/ha.
2. The use of methulfuron methyl herbicide up to a dose of 30 g/ha does not cause poisoning in rice plants until 6 weeks after application.

3. Treatment of methulfuron methyl herbicide starting at a dose of 15 g/ha can increase rice yields.

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