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Research Article
Glyphosate Potassium Salt Dosage Efficacy to Weed Control in Guava Plants

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Abstract
Background and Objective: The presence of weed in guava plants can lead to loss of the yield. Weed control in guava plants using glyphosate potassium salt has never been reported in Indonesia. This research was aimed to determine the potential of glyphosate potassium salt in controlling weed in the guava plants. **Material and Methods:** This research was conducted in the Telaga Sari Village, Sunggal sub-District, Deli Serdang District, North Sumatra Province, Indonesia from June until August 2019. This research used the Randomized Block Design Non-Factorial with the recommended dosage of glyphosate potassium salt (0, 0.25, 0.50, 0.75, 1 L ha^{-1}). Parameters include the weed density (broadleaf, grasses, and sedges) before efficacy, weed toxicity, fresh weight, dry weight, growth reduction, and weed control. Parameters were analyzed using the IBM SPSS Statistics v.20 software. **Results:** The results showed that the dominant weed group in guava plants was found in grasses weed of 52.76%. Glyphosate potassium salt herbicide was showed that significant toxicity to broadleaf, grasses and sedges at 1 and 2 weeks after spraying. Glyphosate potassium salt herbicide at the dose of 1 L ha^{-1} was effective in controlling the fresh weight, dry weight, growth reduction and weed control of broadleaf of 0.79, 0.17 g; 96.61, 79.90% and effective in controlling grasses of 4.11, 2.03 g; 93.63, 84.40% and ineffective in controlling sedges weed. **Conclusion:** Hence it was concluded that, Glyphosate potassium salt herbicide at the dose of 1 L ha^{-1} is highly suitable for controlling the broadleaf and grasses in guava plants.

Key words: Broadleaf, glyphosate potassium, growth reduction, guava plants, sedges weed

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Guava (*Psidium guajava* L.) plant is one of the important fruit crops in North Sumatra Province, Indonesia had produced fluctuations over the past 5 years (2013 to 2017) and had an average production[1] of 11,278.80 tons. One area in North Sumatra that produces the largest guava is Deli Serdang District. Based on observations, farmers in Telaga Sari Village, Sunggal sub-District, Deli Serdang District are dominantly planted of guava. The fluctuations in guava yield in North Sumatra can be caused by the improper cultivation techniques, unbalanced fertilization, soil conditions, lack of optimal management of pests and diseases and could also be caused by the presence weeds in the guava area. Competition of nutrients, water absorption and sunlight between weed and plants can be a cause of the low guava yield. Plant yield losses have been reported due to the presence of weeds in the planting area. Das *et al.*[2] stated that the various herbicides treatment significantly in suppressing weeds and increasing of guava fruit weight. The application of glyphosate 1 L ha^{-1} + 1,200 sodium salt g ai ha^{-1} at 30 days after sprayed can increase the guava fruit weight of 70.30% compared to unsprayed.

Plant production losses must be prevented by weed management and can support sustainable agriculture. Sustainable agriculture for integrated weed management is seen as an approach to reducing environmental contamination and increasing weed control over the long-term[3,4,5] and without excluding the use of herbicides[3,6]. The use of similar herbicides on agricultural land which is continuously less effective in suppressing weeds and can disturb soil fertility caused by herbicide persistence. Colquhoun[7] stated that several families of herbicides have a moderate to long persistence category. The selection of herbicide families that are not-persistent can successfully weed management and support sustainable agriculture. Pesticide Action Network Europe[8] stated that the glyphosate has been used in global around of 50% in controlling of glyphosate-resistant weeds in maize, cotton, soybean, oilseed and sugar beet crops.

Based on interviews with guava farmers in the Telaga Sari Village had obtained the history of weed control using glyphosate and paraquat herbicides at the dose of 14.67 cm^3 L^{-1} with spraying intervals of 2-fold in the year. The dosage used by guava farmer was classified as high, however, weeds grow quickly within a few weeks after spraying. Weed control in guava plants with different salt of glyphosate has never been reported in Indonesia. The research was aimed to determine the potential of glyphosate potassium salt in controlling weed in guava plants.

MATERIAL AND METHODS

Plots determination: The preparation of observation plots had formed the size of 1×1 m with three sample plots at a distance of 1 m from the guava plants (Fig. 1). The sample plot can represent of all vegetation observed in guava plants. The broadleaf, grasses and sedges weed.$plot^{-1}$ were identified.

Research design: This research was conducted in the field of guava farmers in the Telaga Sari Village, Sunggal sub-District, Deli Serdang District, North Sumatra Province, Indonesia (98°33'15.24"E, 03°32'13.86"N) with the altitude of 28 m above sea level. This research used the randomized block design non-factorial with the recommended dosage of glyphosate potassium salt using three replications (Table 1). This research was conducted from June until August 2019.

Calibration spray and application of glyphosate potassium salt: The spray volume was calibrated at 285.71 L ha^{-1} could be presented in Eq. 1[9]. Spraying of glyphosate potassium salt

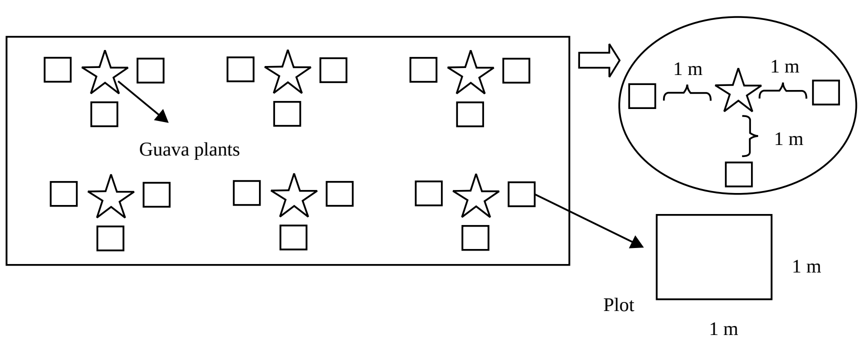

Fig. 1: Weed plot model in guava plants

herbicide (Roundup Powermax 660 SL, Nufarm Indonesia) was conducted in sunlight conditions at 10:00 AM at 32.5°C, the moisture of 57% and air pressure of 1008 hPa.

Parameters and data analysis: The parameters of this research include weed density (broadleaf, grasses and sedges) before efficacy, weed toxicity, fresh weight, dry weight, growth reduction and weed control. The measurement sum of weeds was conducted at 1, 2 and 3 Weeks After Spraying (WAS). Weed toxicity measurements were performed by visual and scoring based on leaf color at 1 and 2 WAS, (score 0 = green, 1 = yellowish-green, 2 = overall in yellow, 3 = brownish yellow, 4 = brown and shrink), then the scoring results are converted to the weed toxicity percentage with the formula score on the treatment compared to the highest score. Weed control was determined based on the number of weed mortality compared to the number of weeds before spraying each group and could be presented in Eq. 2[10]. Weeds that survived at 3 WAS from each treatment were harvested by cutting the base of the weed stem and was dried at 65°C for 48 hrs. Growth reduction was determined based on the dry weight of the weeds had sprayed compared to unsprayed and could be presented in Eq. 3[11].

$$\text{The spray volume calibration} = \frac{\text{Land area of 1 ha}}{\text{Length} \times \text{Width of spray}} \times \text{Water used} \quad (1)$$

$$\text{Weed control (\%)} = \frac{\Sigma\,\text{Mortality weed after spraying}}{\Sigma\ \text{Weed before spraying}} \times 100 \quad (2)$$

$$\text{Growth reduction (\%)} = 100 - \frac{\text{Dry weight of weed after spraying}}{\text{Dry weight of weed at the dose of 0 g ai ha}^{-1}} \times 100 \quad (3)$$

The parameters were analyzed using the one-way ANOVA and the means were followed by DMRT at level 5% using the IBM SPSS Statistics v.20 software.

Table 1: Recommendation dosage of glyphosate potassium salt in guava plants

Plots	Recommendation dosage (L ha^{-1})	Active ingredients of glyphosate potassium (g ai ha^{-1})	Dosage of roundup-powermax (cc L^{-1})
KG_0	0.	0	0
KG_1	0.25	165	0.88
KG_2	0.50	330	1.75
KG_3	0.75	495	2.63
KG_4	1	660	3.50

KG_0: Unsprayed of glyphosate potassium salt, KG_1: Dose recommendation of 0.25 L ha^{-1}, KG_2: Dose recommendation of 0.50 L ha^{-1}, KG_3: Dose recommendation of 0.75 L ha^{-1}, KG_4: Dose recommendation of 1 L ha^{-1}

RESULTS AND DISCUSSION

Weed density before efficacy: The presence of weed density before spraying was presented in Table 2. The dominant weed was found in grasses of 52.76% in the guava plants followed by broadleaf and sedges.

Based on observations in guava area were obtained by grasses weed, such as Cogongrass [*Imperata cylindrica* (L.) P. Beauv], Carpetgrass [*Axonopus compressus (Swartz)* P. Beauv], Paspalum [*Paspalum conjugatum* P.J. Bergius], Junglerice [*Echinochloa colona* (L.) Link], Crabgrass [*Digitaria ciliaris*

Table 2: Weed density before efficacy in guava plants

		Weed density before efficacy(populations)			
Plots	Weeds group	I	II	III	Total
KG_0	Broadleaf	8	21	35	64 pop
	Grasses	95	35	34	164 pop
	Sedges	10	14	9	33 pop
KG_1	Broadleaf	13	14	8	35 pop
	Grasses	19	16	38	73 pop
	Sedges	12	18	18	48 pop
KG_2	Broadleaf	10	12	21	43 pop
	Grasses	44	49	13	106 pop
	Sedges	18	6	8	32 pop
KG_3	Broadleaf	17	25	11	53 pop
	Grasses	30	23	33	86 pop
	Sedges	5	9	46	60 pop
KG_4	Broadleaf	23	59	16	98 pop
	Grasses	48	43	72	163 pop
	Sedges	33	14	17	64 pop
Total	Broadleaf		293 populations (26.11%)		
	Grasses		592 populations (52.76%)		
	Sedges		237 populations (21.12%)		

(Retz.) Koeler], *Bermudagrass* [*Cynodon dactylon* (L.) Pers] and Goosegrass [*Eleusine indica* (L.) Gaertn]. Broadleaf weed include Chinese violet [*Asystasia gangetica* (L.) *T. anderson*], Billygoat [*Ageratum conyzoides* L.], *Fringed spiderflower* (*Cleome rutidosperma* DC], *Spermacoce alata* [*Borreria alata* (Aubl.) DC] and Spreading dayflower [*Commelina diffusa* Burm. f.], while sedges weed only Purple nutsedge [*Cyperus kyllingia* L.]. The grasses weed growth in guava plant is more dominant compared to broadleaf and sedges weed on guava plants caused by seed bank of broadleaf have a long dormancy period. Laude[12] stated that the annual grasses weed have dormancy persisted from one to five months. Burke *et al.*[13] stated that the germination of broadleaf weeds (*Brachiaria platyphylla*) was only 48% at 0.5 cm soil depth at 14 days after planting. Głowacka[14] stated that the sum of grasses weed (*Echinochloa crus-galli*) is more dominant in surviving on mechanical control of 18.0 populations or chemical of 10.3 populations in maize plants compared to broadleaf weed (*Galinsoga parviflora, Chenopodium album, Cirsium arvense, Polygonum lapathifolium*). Uddin *et al.*[15] stated that the abundance of grasses weed of 130.1% was higher compared to broadleaf of 108.5% and sedges of 61.4% in rice and potato cropping patterns.

Weed toxicity assessment: Weed toxicity assessments after spraying with the recommended dosage of glyphosate potassium were presented in Table 3.

Glyphosate potassium herbicide has a significant toxicity effect on all weed groups (broadleaf, grasses and sedges) at 1 and 2 WAS. Effectiveness of glyphosate potassium salt herbicide at the dose of 1 L ha^{-1} could be caused the weed toxicity of 89.25, 96.25 and 43.25% respectively for broadleaf, grasses and sedges at 2 WAS (Table 3).

The effect of glyphosate potassium herbicide at the dose of 0.75 until 1 L ha^{-1} on the highest toxicity symptoms were found in grasses, followed by broadleaf and sedges weed. Toxicity symptoms can be seen were brownish yellow, shrink to death (Fig. 2a-e).

Visual observations showed that an increased total of broadleaf and grasses weed seen brownish yellow, shrink to death along with an increased dose of glyphosate potassium salt at 1 until 3 WAS. The highest toxicity symptoms of glyphosate potassium salt herbicide were found in grasses weed, followed by broadleaf and sedges. It was linear with the control percentage in grasses of 88.40% (Fig. 3b) and was higher compared to broadleaf and sedges of 79.90% and 13.25% (Fig 3a and c), respectively. According to Monaco *et al.*[16] stated that the effects of glyphosate herbicides on active mobile in the xylem and phloem tissue of weed resulting in chlorosis, necrosis and death at 5-10 days after spraying. Golob *et al.*[17] stated that the formulation of the potassium salt of glyphosate can be controlling all weed species of 83.8, 91.8 and 93.8% and was higher compared to isopropylamine and diammonium salts at 14, 28 and 56 days after spraying at the Pullman, Washington, United States. Kurniadie *et al.*[18] stated that the glyphosate potassium herbicide at the dose of 660 g L^{-1} without rainfall was effectively controlled grasses weed (*Imperata cylindrica*) with the percentage of damage symptoms of 94% and higher compared to broadleaf weeds (*Asystasia intrusa*) of 60% at 2 WAS.

Weed biomass: Biomass of weed after spraying with recommendation dosage of glyphosate potassium was presented in Table 4.

Glyphosate potassium herbicide has a significant effect in controlling the fresh weight and dry weight of broadleaf and grasses weed, however it is less effective in sedges weed. Glyphosate potassium herbicide at the dose of 1 L ha^{-1} was effectively to decrease the fresh- and dry weight in the broadleaf weed of 0.79 g plot^{-1} and 0.17 g plot^{-1}, respectively. Glyphosate potassium herbicide at the dose of 0.25 until 1 L ha^{-1} was effectively decreased the fresh weight and dry weight of grasses weed. Glyphosate potassium herbicide at

Table 3: Weed toxicity assessment on glyphosate potassium salt-sprayed in guava plants at 1 until 2 weeks after spraying (WAS)

Glyphosate potassium salt dosage (L ha^{-1})	Weed toxicity assessment plot^{-1} and percentage 1 WAS	2 WAS
Broadleaf weed		
0	0.00±0.00^{d} (0.00%)	0.00±0.00^{c} (0.00%)
0.25	0.80±0.03^{cd} (20.00%)	1.57±0.31^{b} (39.25%)
0.50	1.47±0.33^{bc} (36.75%)	2.18±0.37^{b} (54.50%)
0.75	2.13±0.36^{ab} (53.25%)	3.23±0.36^{a} (80.75%)
1	2.42±0.31^{a} (60.50%)	3.57±0.33^{a} (89.25%)
Grasses weed		
0	0.00±0.00^{b} (0.00%)	0.00±0.00^{c} (0.00%)
0.25	0.85±0.52^{b} (21.25%)	1.90±0.96^{b} (47.50%)
0.50	2.13±0.36^{a} (53.25%)	2.95±0.03^{ab} (73.75%)
0.75	2.57±0.21^{a} (64.25%)	3.55±0.33^{a} (88.75%)
1	3.13±0.31^{a} (78.25%)	3.85±0.08^{a} (96.25%)
Sedges weed		
0	0.00±0.00^{c} (0.00%)	0.00±0.00^{c} (0.00%)
0.25	0.52±0.26^{bc} (13.00%)	0.71±0.02^{b} (17.75%)
0.50	0.80±0.05^{abc} (20.00%)	1.10±0.33^{ab} (27.50%)
0.75	1.13±0.36^{ab} (28.25%)	1.57±0.35^{a} (39.25%)
1	1.35±0.33^{a} (33.75%)	1.73±0.19^{a} (43.25%)

Different lowercase letters mean significant difference by DMRT at level of 5%±standard error

Fig. 2(a-e): Observation weed on glyphosate potassium salt-sprayed in guava plants
Recommendation dosage (a: 0 L ha^{-1}, b: 0.25 L ha^{-1}, c: 0.50 L ha^{-1}, d: 0.75 L ha^{-1}, E: 1 L ha^{-1}), Weeks after spraying (1: 1 WAS, 2: 2 WAS, 3: 3 WAS)

the dose of 1 L ha^{-1} was showed the highest dose decreasing biomass of broadleaf and grasses weed. A decreased the biomass of grasses weeds along with an increased at the dose of glyphosate potassium. The response of glyphosate active ingredients can be caused inhibit of weed metabolism resulting inhibit the production of weed biomass. According to Franz *et al.*[19], Duke *et al.*[20] stated that glyphosate can inhibit the metabolism of the plant by inhibiting amino acid biosynthesis through inhibition shikimate acid pathway in plants. Dixit *et al.*[21] stated that giving of glyphosate potassium at the dose of 900 until 3,600 g ha^{-1} can control the total dry weight of 100% in Genetically Modified Organism of corn plants (GMO) for 21 DAS.

Weed control: Weed control after spraying with the recommended dosage of glyphosate potassium was

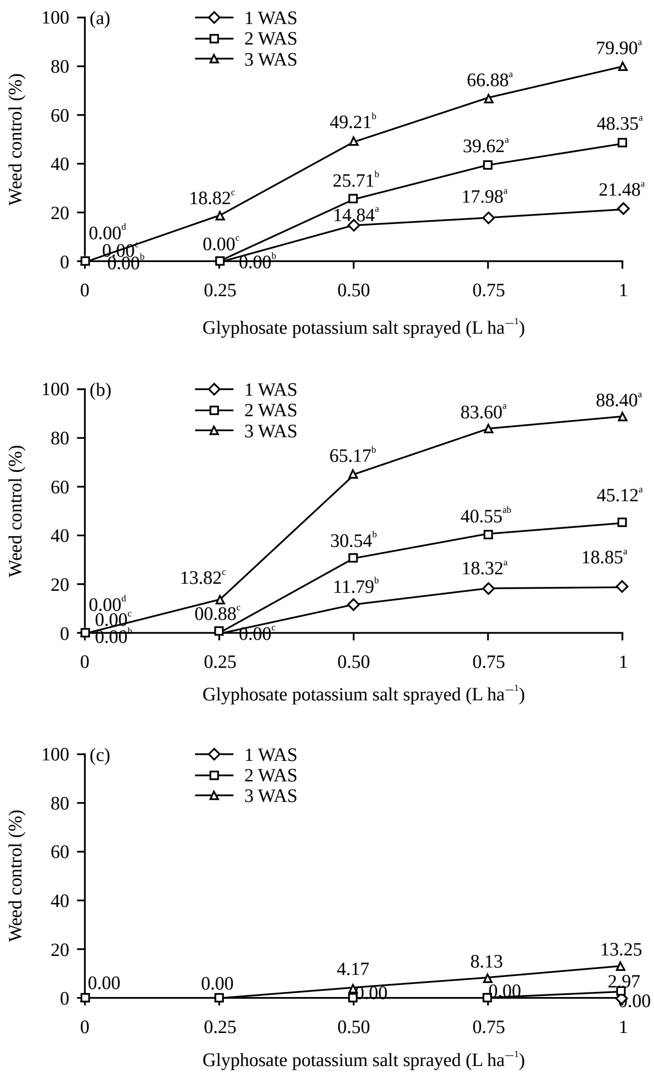

Fig. 3(a-c): Weed control of the dosage of glyphosate potassium salt-sprayed in guava plants

Different lowercase letters mean a significant difference by DMRT at level of 5%, (a): Broadleaf, (b) Grasses and (c) Sedges

presented in Fig. 3. Glyphosate potassium herbicide was significantly effective in controlling broadleaf and grasses weed, but less effective in sedges weed at 3 WAS.

The controlling rate of glyphosate potassium herbicide ranged from 66.88-79.90% for broadleaf and ranged from 83.60-88.40% for grasses. Glyphosate potassium salt herbicide can be recommended in controlling the broadleaf of 79.90% and grasses of 88.40% were higher compared to sedges weed of 13.25% at 3 WAS. It was caused by potassium cation (K^+) have strongly bound to glyphosate negative molecules that it can increase the effectiveness of glyphosate. In overall, glyphosate was inhibited the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS). Glyphosate potassium was inhibited the metabolism and biomass production of weed. It was evidenced by the dry weight of broadleaf and grasses weed on the glyphosate potassium at the dose of 0.75 until 1 L ha^{-1} were classified as lower compared to other doses as shown in Table 4. According to Nalewaja and Matysiak[22] stated that the addition of KOH salt (hydroxide potassium) on glyphosate was not antagonistic. The addition of KOH on 400 g ai ha^{-1} glyphosate can decrease the fresh weight wheat of 98%. Monaco *et al.*[16] stated that glyphosate inhibits the EPSPS that an increase in shikimic acid in the pathway of aromatic amino acid biosynthesis. Tampubolon *et al.*[23] reported that 364 of 421 *Eleusine indica* populations were classified moderate until resistant to glyphosate isopropylamine salt at the dose of two L ha^{-1} from oil palm plantations in North Sumatra. Therefore, glyphosate isopropylamine salt is less effective in controlling *Eleusine indica*.

Table 4: Weed biomass on glyphosate potassium salt-treated in guava plants at 3 weeks after spraying (WAS)

Glyphosate potassium salt dosage (L ha^{-1})	Weed biomass plot^{-1} (g) Fresh weight	Dry weight
Broadleaf weed		
0	19.85±6.96^c	5.00±1.47^b
0.25	19.38±2.70^c	4.77±0.76^b
0.50	12.39±2.09^{bc}	1.80±0.75^a
0.75	4.28±1.98^{ab}	1.09±0.35^a
1	0.79±0.25^a	0.17±0.06^a
Grasses weed		
0	99.63±31.32^b	31.90±10.41^b
0.25	36.64±8.87^a	14.14±3.62^a
0.50	20.17±4.28^a	7.76±1.45^a
0.75	8.61±2.89^a	3.67±1.08^a
1	4.11±1.60^a	2.03±0.94^a
Sedges weed		
0	5.47±0.34^{ns}	1.99±0.39^{ns}
0.25	6.65±1.91^{ns}	1.83±0.88^{ns}
0.50	4.28±1.89^{ns}	1.58±0.66^{ns}
0.75	3.71±1.51^{ns}	1.48±0.53^{ns}
1	2.81±0.65^{ns}	1.08±0.20^{ns}

Different lowercase letters mean significant difference by DMRT at level of 5%±standard error; ns: Not significant

Growth reduction: Growth reduction of weed after spraying with the recommended dosage of glyphosate potassium was presented in Fig. 4. The highest growth reduction was found in the broadleaf weed of 96.61% compared to grasses and sedges of 93.63 and 45.65%, respectively with the dose of 1 L ha^{-1} glyphosate potassium.

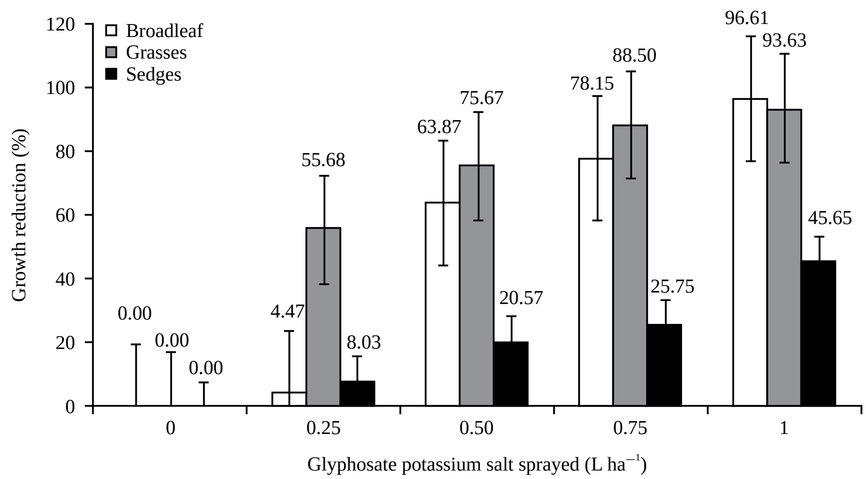

Fig. 4: Growth reduction of weeds on glyphosate potassium salt-sprayed in guava plants
Vertical bars indicate±standard error

Glyphosate potassium salt herbicide at the dose of 0.25-0.75 L ha^{-1} had the identical growth reduction pattern, the highest growth reduction found in the grasses and followed by broadleaf and sedges along with an increased dose of glyphosate potassium salt herbicide. It was suggested that glyphosate potassium herbicide was dominantly effective in the growth reduction of broadleaf weed. It was linear with the dry weight of broadleaf weed at the dose of 1 L ha^{-1} of glyphosate potassium only 0.17 g plot^{-1} as shown in Table 4. According to Bentivegna *et al.*[24] stated that the glyphosate potassium herbicide at the dose of 270 g ai ha^{-1} was effectively (100%) in controlling *Diplotaxis tenuifolia*, *Cynara cardunculus*, *Avena barbata*, *Lolium perenn*e in the early and middle stages of growth with the dry weight of 0 g. Kurniadie *et al.*[18] stated that the potassium glyphosate of 660 g L^{-1} herbicide without rainfall can be controlling the dry weight of *Asystasia intrusa*, *Imperata cylindrica*, *Borreria alata*, *Paspalum conjugatum*, *Ageratum conyzoides*, *Setaria plicata* of 0 g at 3 WAS. Tampubolon *et al.*[25] reported that the growth reduction of glyphosate-resistant *Eleusine indica* was higher if controlled with glufosinate ammonium and triclopyr compared to glyphosate.

The main finding of the research, such as the effectiveness of glyphosate potassium salt dominant in controlling grasses weed and followed by broadleaf weed on guava plants in Indonesia, the weed toxicity information of glyphosate potassium salt was effective to control grasses, broadleaf and sedges weed at one week after spraying, obtained the growth reduction pattern of grasses, broadleaf and sedges weed from the dose of 0 until 1 L ha^{-1} of glyphosate potassium salt.

CONCLUSION

The dominant weed group in the guava plants was found in grasses weed of 52.76%. Glyphosate potassium salt herbicide was showed the effect significant to toxicity symptoms on broadleaf, grasses and sedges weed at 1 until 2 WAS. Glyphosate potassium salt herbicide at the dose of 1 L ha^{-1} was significantly effective in controlling broadleaf and grasses and less effective in sedges weed. Glyphosate potassium salt herbicide at the dose of 1 L ha^{-1} was significantly effective in suppressing fresh weight, dry weight, growth reduction and controlling the broadleaf weed and effective in suppressing grasses weed at 3 WAS.

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SIGNIFICANCE STATEMENT

This study discovered the effectiveness of glyphosate potassium salt herbicide that can be beneficial for farmers and plantations of guava as an alternative in controlling broadleaf and grasses weeds in order to support the yield of guava plants. This study will help the researchers to uncover the critical areas of glyphosate potassium salt herbicide. Thus a new theory on the weed toxicity of glyphosate potassium salt more effective to control the broadleaf weed may be arrived at the field of guava plants.

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