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Efficacy of Sequential Applications of MSMA in Combination with Diuron for Weed Control in Young Oil Palm Circle

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Circle weeding within the area covered by oil palm canopy is one of the most important methods of weed management in young oil palm plantations. Application of herbicide mixture has been a common practice to control mixed weeds in oil palm and it also helps to delay herbicide resistance. This study aims to determine the efficacy of MSMA in combination with diuron for weed control in young oil palm circles under field conditions. Three sequential applications of the herbicide combinations with 45 days' interval were carried out while weed control and appearance of oil palm spears were assessed throughout the 18 weeks' of experimental period. The results showed that MSMA + diuron at a rate of 2 945 + 600 g per hectare provided 86 per cent weed control in young oil palm circles with healthy oil palm spears after three sequential applications although scorching was apparent at lower fronds due to drift of spray droplets. Increasing the rate of MSMA + diuron to 5 890 + 1 200 g per hectare gave comparable results and the treatment did not exhibit phytotoxic effect to spears of young oil palm after three sequential applications. These findings suggest that a combination of MSMA + diuron at a rate of 2 945 + 600 g per hectare could be applied to control weeds in young oil palm circle without causing phytotoxicity to the oil palm spears although scorching was observed at the lower fronds.

Keywords*: Diuron, herbicide mixture, spears, sequential.*

Weed management in the oil palm industry consists of circle weeding within the area covered by the crop canopy and clearing weeds from the harvesting paths and planting rows; and conducting selective weeding to control isolated colonies of weeds or small patches. Weed control is the second highest resource demand practiced after manuring in oil palm cultivation (Chan & Yusof, 1998). Herbicide application still remains the major strategy for weed control in oil palm plantations although biological, mechanical and cultural methods are being practiced. However, heavy dependency on herbicides as the primary method of weed control could cause intense selection pressure, leading to the evolution of herbicide resistance in weed (Dilipkumar *et al*., 2017).

Monosodium methylarsonate (MSMA) is a contact herbicide commonly applied as post emergence control of grassy weeds in turf,

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cotton and non-crop areas (Vencill, 2002). Diuron is a non-selective, systemic herbicide and applied as post and pre emergence control of weeds in corn, banana, papaya and pineapple by inhibiting photosystem II (Shaner, 2014). In Malaysia, both herbicides have been registered in sugarcane, oil palm and rubber for weed control (DOA, 2019). The use of herbicide mixture is widely recommended for managing herbicide resistance (Beckie & Rebound, 2009). David *et al*. (1997) reported that herbicidal activity of MSMA can be further improved after mixing with cyanazine, diuron, fluometuron, or oxyfluorfen. A previous study by Sim *et al*. (2018) has demonstrated that MSMA plus diuron with or without glufosinate could provide excellent control of goosegrass, a problematic grassy weed in young oil palm and nursery, that have evolved resistance across glyphosate (Cha *et al*., 2014a), glufosinate (Chuah *et al*., 2010; Chuah *et al*., 2016) and fluazifop (Cha *et al*., 2014b). There is still limited study on MSMA in combination with diuron for weed control in young oil palm. Thus, this study aims:

i) to determine efficacy of sequential applications of MSMA in combination with diuron for weed control in young oil palm circles, and
ii) to evaluate phytotoxicity of the sequential herbicide treatments on young oil palm trees.

MATERIALS AND METHODS

The experimental plots were established at a young oil palm farm (18 months old) in Pinang Tunggal, Seberang Perai, Penang, Malaysia (GPS location: 5.535, 100.513). There were 18 plots where each plot measuring 12.6 m^2 of circular area (radius = 2 m) were established. The trial areas were exposed to sunlight with less than 30 per cent shade. The weeds were treated by using a conventional knapsack sprayer with 5/64 in. fan jet nozzle calibrated to give a spraying volume of 450 L per hectare. The lower fronds of oil palm were lifted up to avoid direct contact of herbicide spray. Weekly rainfall data during the experiment period were obtained from a meteorological station near the experiment area. The monthly rainfall ranged from 111 to 335 mm throughout the experimental period. The experiment was arranged in a randomised complete block design with three different herbicide treatments and one weedy check (*Table 1*) with three replications where each replicate consists of four oil palm trees. Application of glufosinate was served as positive control.

Three sequential applications of each herbicide treatment at 45 days' interval were conducted throughout the 18 weeks in the field trial. Assessment was done based on visual estimation of percentage kill on a mixture of weeds including *Ageratum conyzoides* (5%), *Amaranthus viridis* (5%), *Asystasia*

TABLE 1
LIST OF HERBICIDE TREATMENTS

Active ingredient	*% (w/w)*	*Formulation*	*Application rate (g a.i./ha)*
MSMA + diuron (premix)	39.5 + 7.8	Suspension concentrate	2945+600
MSMA + diuron (premix)	39.5 + 7.8	Suspension concentrate	5890+1200
Glufosinate	13.5	Soluble concentrate	495

gangetica (5%), *Cleome rutidosperma* (15%), *Commelina diffusa* (10%), *Cyperus iria* (5%), *Digitaria adscendens* (2%), *Echinochloa colona* (15%), *Eleusine indica* (15%), *Emilia sonchifolia* (3%), *Euphobia hirta* (5%) and *Tridax procumbens (*15%) found in the young oil palm circle at 2, 4 and 6 weeks after treatment (WAT) for the first application. These weed species were less than 35 cm in height at the vegetative and flowering stages before herbicide treatments. The assessment was also done at 2, 4 and 6 WAT for second and third applications, respectively. Visual rating was given based on the percentage of scorching where 0 per cent denotes no kill symptom on the target weed while 100 per cent denotes plant death or completely scorched. Phytotoxicity of herbicide treatments towards young oil palm was assessed based on symptom injuries of spear such as scorching, twisting and bending. Data were subjected to One-way ANOVA and means were compared by Tukey test at 5 per cent of significant level using SPSS (Version 25).

RESULTS AND DISCUSSION

MSMA in combination with diuron for weed control in young oil palm circle

Efficacy of different herbicide treatments for weed control in young oil palm circles throughout the 18 weeks under field conditions is shown in *Table 2* and *Figure 1*. At 2 WAT, diuron combined with MSMA at twice the recommended rate (MSMA + diuron at 5 890 + 1 200 g a.i./ha) had significantly ($P<0.05$) better control of weed as compared to diuron plus MSMA at the recommended rate (MSMA + diuron at 2 945 + 600 g a.i./ha) and glufosinate alone (glufosinate 495 g a.i./ha). At 4 WAT, the control rate dropped regardless of any treatments. Weed control percentage from glufosinate at 495 g a.i. per hectare dropped drastically from 82 per cent to 66 per cent. Surprisingly, *C. rutidosperma, C. diffusa* and *A. conyzoides* that were killed 100 per cent at 2 WAT re-germinated or regrew. This result was expected because glufosinate is a contact herbicide with no soil residual activity (Shaner, 2014). However, MSMA + diuron at 5 890 + 1 200 g a.i. per hectare had the highest weed control percentage with a mean value of 86 per cent, implying that MSMA + diuron at 5 890 + 1 200 g a.i. per hectare is able to reduce weed seed bank and prolong the duration of weed control because diuron has soil residual activity (Shaner, 2014) (*Table 2* & *Figure 1*).

At 6 WAT, the weed control of all treatments dropped further. Though there was no effective weed control by all treatments, however, MSMA + diuron at 5 890 + 1 200 g a.i. per hectare still remained as the treatment with the highest control rate with 70 per cent control. Control rates of MSMA + diuron at 2 945 + 600 g a.i. per hectare and glufosinate at 495 g a.i. per hectare dropped drastically from 72 per cent to 53 per cent and 66 per cent to 38 per cent, respectively. The newly emerged and regrown weeds at 4 WAT had grown and more new weed seedlings also began to emerge at 6 WAT. A second application of herbicide treatment was conducted on the same day as 6 WAT after the assessment was done (*Table 2* & *Figure 1*).

At 8 WAT, weed control of herbicide treatments increased and the percentage control was much higher as compared to that observed at 2 WAT during the first application. MSMA + diuron at 5 890 + 1 200 g a.i. per hectare reached a control rate of 93 per cent, followed by MSMA + diuron at 2 945+ 600 g a.i. per hectare with a control rate of 89 per cent. Meanwhile, glufosinate at 495 g a.i. per

TABLE 2
EFFICACY OF SEQUENTIAL APPLICATIONS OF MSMA IN COMBINATION WITH SELECTED HERBICIDES FOR WEED CONTROL IN YOUNG OIL PALM CIRCLE

Herbicide treatments	*Weed control rating (%)*								
	2WAT	*4WAT*	*6WAT*	*8WAT/ 2WA2A*	*10WAT/ 4WA2A*	*12WAT/ 6WA2A*	*14WAT/ 2WA3A*	*16WAT/ 4WA3A*	*18WAT/ 6WA3A*
Diuron + MSMA (x) (2 945+ 600 g a.i./ha)	84 ^{a}	72 ^{ab}	53 ^{a}	89 ^{ab}	71 ^{b}	66 ^{b}	95 ^{ab}	92 ^{ab}	86 ^{b}
Diuron +MSMA (2x) (5 890+ 1 200 g a.i./ha)	92 ^{b}	86 ^{b}	70 ^{b}	93 ^{b}	86 ^{c}	78 ^{c}	98 ^{b}	95 ^{b}	89 ^{b}
Glufosinate (495 g a.i./ha)	82 ^{a}	66 ^{a}	38 ^{a}	85 ^{a}	60 ^{a}	47 ^{a}	94 ^{a}	87 ^{a}	77 ^{a}
Weedy check (untreated control)	0	0	0	0	0	0	0	0	0

Note:
WA2A = Weeks after 2nd application; WA3A = Weeks after 3rd application.
Different subscripted letters within the same column indicate significant difference for one another after Tukey test at 5% of significant level.
Weed control was rated on 0 to 100% scale; 0 denotes no scorching symptom whereas 100% denotes complete plant death. (x) = recommended rate

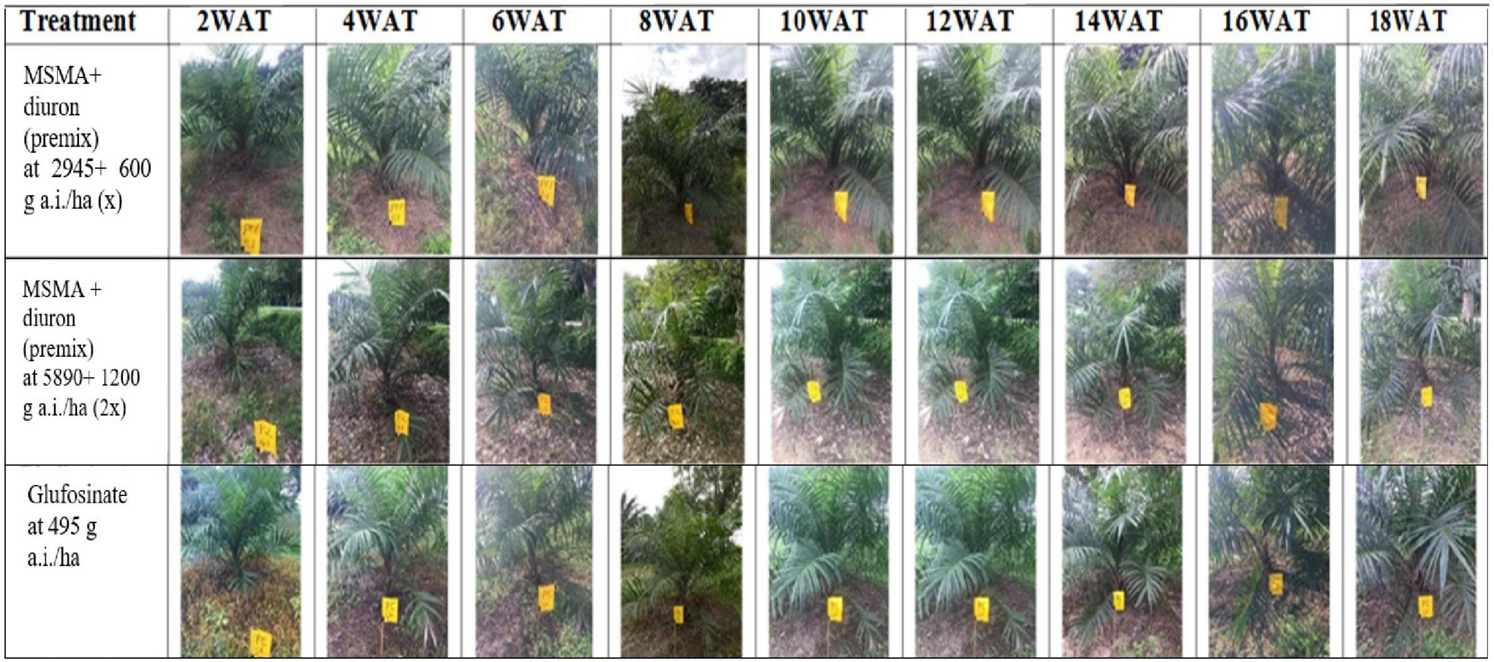

Figure 1 Efficacy of three sequential applications of herbicide treatments for weed control in the young oil palm circle within 18 weeks of assessment. (WAT = Week After Treatment)

hectare had the lowest weed control rate at 85 per cent (*Table 2* & *Figure 1*).

At 10 WAT, control rates of all treatments began to decline. MSMA + diuron at 5 890+ 1 200 g a.i. per hectare had a statistically significant difference ($P < 0.05$) with MSMA + diuron at 2 945+ 600 g a.i. per hectare and glufosinate at 495 g a.i. per hectare. Despite the drop-in control rate, MSMA + diuron at 5 890+ 1 200 g a.i. per hectare still had the highest control rate with 86 per cent weeds being under control, followed by MSMA + diuron at 2 945 + 600 g a.i. per hectare with a control rate of 71 per cent. Similarly, glufosinate at 495 g a.i. per hectare provided the lowest control rate with only a mean value of 60 per cent weeds being under control (*Table 2* & *Figure 1*).

At 12 WAT, the control rate of all treatments further dropped. However, MSMA + diuron at 5 890 + 1 200 g a.i. per hectare still remained as the treatment with the highest control rate of 78 per cent, followed by MSMA + diuron at 2 945 + 600 g a.i. per hectare with a control rate of 66 per cent. Throughout the 12 weeks of assessment, it is evident that the treatments followed a consistent trend with MSMA + diuron at 5 890+ 1 200 g a.i. per hectare being the most effective treatment to control the weeds, followed by MSMA + diuron at 2 945 + 600 g a.i. per hectare and glufosinate at 495 g a.i. per hectare. A third application of herbicide treatments also was conducted after 12 WAT (*Table 2* & *Figure 1*).

At 14 WAT, the control rates of all treatments increased. The increase in control rates were expected for all treatments due to a third application of treatments. The control rates of all treatments were even higher when compared to the results obtained from the first and second applications. MSMA + diuron at 5 890 + 1 200 g a.i. per hectare still remained as the treatment with the highest control rate with a mean value of 98 per cent weeds being under control, followed by MSMA + diuron at 2 945 + 600 g a.i. per hectare and glufosinate at 495 g a.i. per hectare with control rates of 95 per cent and 94 per cent, respectively (*Table 2* & *Figure 1*).

At 16 WAT, the control rates of all treatments dropped slightly but MSMA + diuron at 5 890 + 1 200 g a.i. per hectare was still the treatment with the highest control rate and the control rate was 95 per cent. Glufosinate at 495 g a.i. per hectare remained as the treatment with the lowest weed control rate and its control rate dropped by 7 per cent when compared to that of 14 WAT. The decrease in control rate is due to the emergence of new weed seedlings (*Table 2* & *Figure 1*).

At 18 WAT, glufosinate at 495 g a.i. per hectare had a statistically significance ($P < 0.05$) with MSMA + diuron at 2 945 + 600 g a.i. per hectare and MSMA + diuron at 5 890 + 1 200 g a.i. per hectare. The control rates of all treatments dropped slightly. MSMA + diuron at 5 890 + 1 200 g a.i. per hectare still maintained as the treatment with the highest control rate with 89 per cent of weeds being under control. Glufosinate at 495 g a.i. per hectare still remained as the treatment with the lowest control rate and its control rate had declined to 77 per cent when compared to that of 16 WAT. The drop-in control rate in this assessment is due to emergence of new weed seedlings. This result is expected because glufosinate at 495 g a.i. per hectare is a contact herbicide with no soil residual activity.

Phytotoxicity of MSMA in combination with diuron towards young oil palm

The appearance of oil palm spears after three sequential applications of herbicide treatments in young oil palm circle under field conditions

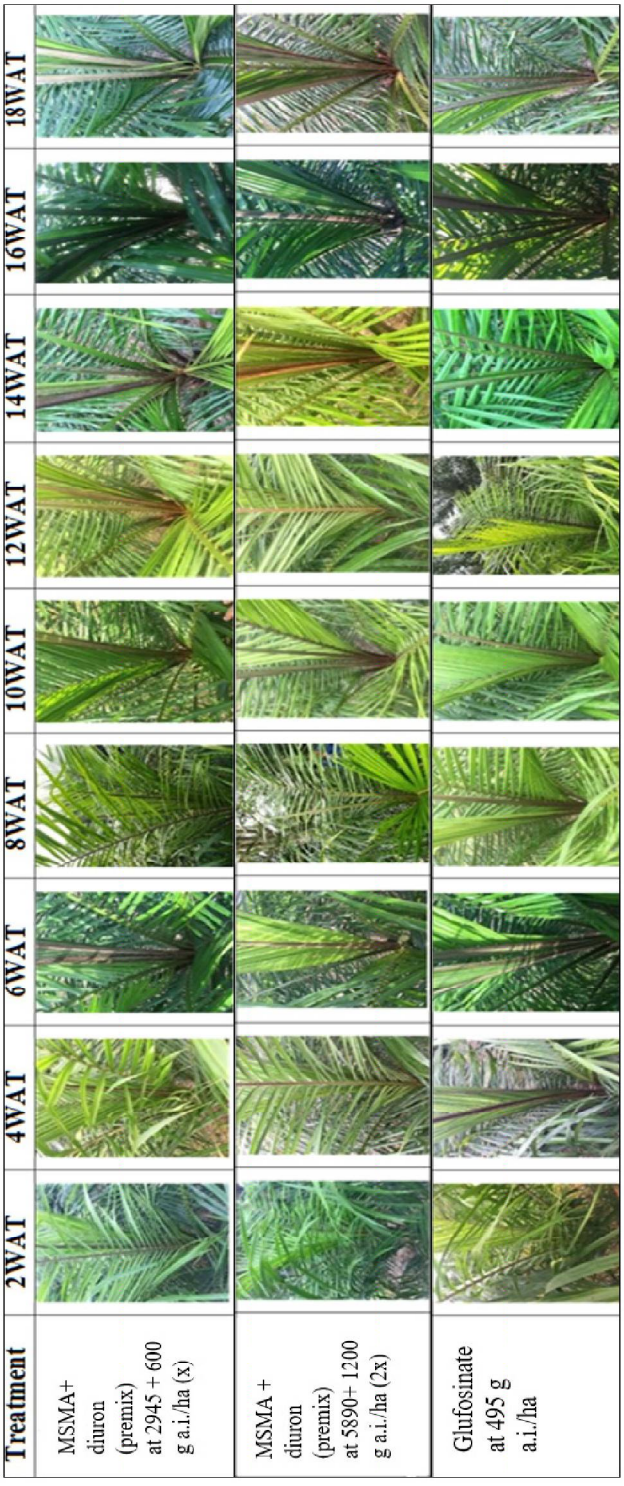

Figure 2 Appearances of young oil palm spears after sequential application of herbicide treatments in young palm circle within 18 weeks of assessment. (WAT = Week After Treatment)

is shown in *Figure 2*. During the 18 weeks of assessment, no phytotoxic symptom was observed for spears of young oil palm although scorching was apparent at some fronds near to soil surface after each herbicide treatment due to drift of spray droplet. The scorching on the fronds did not inhibit the growth of the oil palm trees because the trees could recover when treated with diuron + MSMA at twice the recommended rate for three sequential applications. These findings suggest that all treatments are safe to be applied in young oil palm circle.

The findings of this study clearly show that a combination of MSMA + diuron at the recommended rate of 2 945 + 600 g a.i. per hectare provides excellent weed control in young oil palm circles without causing phytotoxicity to the oil palm spears. Although efficacy of glufosinate at 495 g a.i. per hectare for weed control is mostly comparable to that of MSMA + diuron at 2 945 + 600 g a.i. per hectare throughout the 18 weeks of assessment. The cost comparison revealed that MSMA + diuron at 2 945 + 600 g a.i. per hectare is the most cost effective treatment (*Table 3*).

CONCLUSIONS

A combination of MSMA + diuron at the recommended rate of 2 945 + 600 g per hectare provides excellent weed control in young oil palm circle without causing phytotoxicity to the oil palm spears. Furthermore, it has a longer duration of weed control when compared to that of glufosinate. Interestingly, three sequential applications of MSMA + diuron at 5 890 + 1 200 g per hectare (twice recommended rate) does not exhibit phytotoxic effect to spears of young oil palm although scorching was apparent in some fronds near to the soil surface after the herbicide treatment.

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TABLE 3
COST COMPARSION OF HERBICIDE TREATMENTS

Active ingredient	*% (w/w)*	*Application rate (g a.i./ha)*	*Cost of herbicide (RM/ha)*
MSMA + diuron (premix)	39.5 + 7.8	2 945 + 600	90
MSMA + diuron (premix)	39.5 + 7.8	5 890 + 1 200	180
Glufosinate	13.5	495	124

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