

Glyphosate herbicide is one of the major weed control products that are being used in oil palm plantations and in other major crop areas in Malaysia. The total volume of glyphosate marketed in Malaysia is estimated to be about 15 million litres, which is valued around RM 250 million a year. In glyphosate formulations, an adjuvant is usually added or incorporated to enhance the effectiveness of the products.

Adjuvants can be categorized into three groups, *i.e.*, spray modifiers, activators and utility modifiers. Spray modifiers improve the wetting and spreading properties of a spray solution by lowering its surface tension. This type of adjuvant is probably more important for non-systemic chemicals that require more complete coverage for effectiveness. An activator adjuvant enhances foliar absorption of systemic chemicals, thus, increasing their biological activity. Utility modifiers, on the other hand, are antifoam agents, co-solvents, *etc.*

In weed control, an adjuvant lowers the surface tension of the spray droplets, increasing their spread over the surface of the foliage, and so enhances the uptake and efficacy of herbicides. Therefore, this can also lower the application dosage per hectare as well as broaden the activity spectrum of the herbicides. However, this project only focuses on the application of palm oil-based adjuvants (or surfactants) in glyphosate isopropylamine (IPA) 41% and glyphosate monoammonium (MA) 33.6% herbicide formulations.

GLYPHOSATE HERBICIDES

Glyphosate or N-(phosphonomethyl) glycine is one of the most important organophosphorus herbicides. It was initially marketed under the

trade name *Roundup* by Monsanto Co. USA, in the glyphosate isopropylamine salt formulation (*Figure 1*). Recently, there is a new glyphosate derivative, known as glyphosate monoammonium (*Figure 2*), which was specially invented, patented (utility patent) and produced by Ancom Crop Care Sdn Bhd. It has been registered under the brand name *AmmoTM Supre* with the Pesticides Board of Malaysia, Ministry of Agriculture, since 1998. Both types of glyphosates are highly soluble in water and thus suitable for herbicidal use.

Glyphosate, in general, is a systemic, non-volatile, relatively non-selective and non-residual post-emergence herbicide. Its herbicidal action is by inhibiting amino acid (aromatic) metabolism in plants. It is a non-selective, post-emergence translocated herbicide, effective against both annual and perennial grasses and certain broad-leaf weeds. Glyphosate IPA has relatively low mammalian toxicity, and is categorized as a Class III pesticide. However, glyphosate MA has even lower mammalian toxicity, and is categorized under the Class IV pesticides by the Pesticides Board of Malaysia.

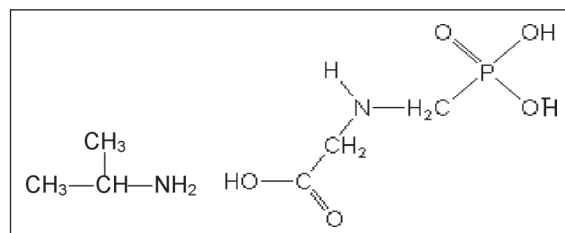


Figure 1. Glyphosate isopropylamine (IPA) chemical structure.

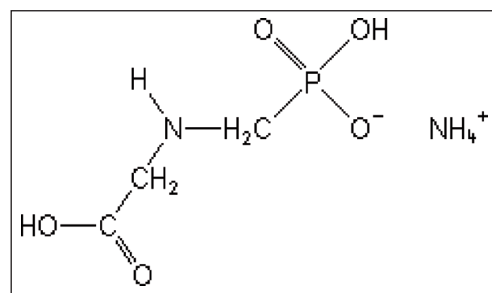


Figure 2. Glyphosate monoammonium (MA) chemical structure.

* Ancom Crop Care Sdn Bhd.

**A joint project between Malaysian Palm Oil Board and Ancom Crop Care Sdn Bhd.

TECHNOLOGY INNOVATION

In recent years, the application of tallow amine ethoxylates as adjuvants in the conventional glyphosate herbicide formulations is limited or not allowed for use in and around waterways in certain countries, like Australia, because these amine-based ethoxylate surfactants have cationic charges that can react with other oppositely charged surfactants or pesticides. They also have posed an increasingly negative effect in the form of toxicity to the eyes and to aquatic life. The greater the cationic charge, the worst are the toxic effects on aquatic life and to the eyes.

A palm oil-based adjuvant, which is derived from palm oil, is an environmental-friendly compound. As it is a natural oil, it is renewable, biodegradable, non-flammable, harmless to the environment and is less toxic to the end-user. It is considered safer than other conventional adjuvants because it causes fewer medical problems or allergies to the operator. Therefore, the development and application of palm oil-based adjuvants (or surfactants) in glyphosate herbicides are deemed to be excellent in developing alternatives to address the issues of aquatic friendliness and to contribute to the better safety of the workers.

Palm Oil-based Adjuvants in Glyphosate Herbicide Formulations: Small-scale Screening Trials

The laboratory-scale glyphosate herbicide formulations were prepared with nine types of adjuvant/blended adjuvants at 7.5%, 10% and 12.5% (w/w) (Figure 3).



Figure 3. Glyphosate-herbicide formulations using blended palm oil-based adjuvants.

All the samples, except two, were found to be stable after being kept in a forced-draft oven at 50°C for more than two weeks. These seven stable formulated products, which were coded as MAGPIPA-S1 to MAGPIPA-S7 for glyphosate IPA formulations, and MAGPMA-S1 to MAGPMA-S7 for glyphosate MA formulations, were further

tested for their bioefficacy on weeds in a glasshouse at Universiti Putra Malaysia (UPM). The trials compared the formulations with the commercial glyphosate IPA 41% (or *Roundup* and *Asset*) and commercial glyphosate MA 33.6% (or *AmmoTM Supre*).

Small-scale screening Trial 1 found that the blended palm oil-based adjuvants S3 and S4 in glyphosate IPA 41% (w/w) were the most effective in controlling two types of weeds, *Paspalum conjugatum* (grassy weeds) and *Asystasia intrusa* (broad-leaf weeds) compared to the other palm oil-based blended adjuvants (S1, S2, S5, S6, S7). Moreover, the blended palm oil-based adjuvants S3 and S4 in glyphosate IPA 41% (w/w) were as effective as the commercial glyphosate formulations *Roundup*, *Asset* and *AmmoTM Supre*.

Furthermore, small-scale screening Trial 2 found that the blended palm oil-based adjuvants S6 and S7 in glyphosate MA 33.6% (w/w) were the most effective in controlling both types of weeds compared to the other blended adjuvants (S1, S2, S3, S4, S5). Indeed, blended palm oil-based adjuvants S6 and S7 in glyphosate MA 33.6% (w/w) were as effective as the commercial *AmmoTM Supre*, *Roundup* and *Asset* (Figure 4).

The most effective palm oil-based adjuvants (i.e., S3, S4, S6 and S7) from the small-scale trials were further studied to evaluate their bioefficacy for weed control in mature oil palm and rubber plantations.

Field Bioefficacy Trials

As described previously, the glyphosate IPA and glyphosate MA formulations were effective on grassy weeds such as *Ottochloa nodosa*, *Paspalum conjugatum*, *Axonopus compressus* and other soft grassy weeds as well as broad-leaf weeds found in plantation crops. Field Trial 1 was carried out to evaluate and determine which type of blended palm oil-based adjuvant (S3 or S4) at 7.5%, 10% and 12.5% (w/w) concentrations in glyphosate IPA 41% formulations would be the best for the post-emergence control of mixed weeds in a mature oil palm plantation.

Furthermore, field Trial 2 was carried out to evaluate and determine which blend of S6 or S7 at 7.5%, 10% and 12.5% (w/w) concentrations in glyphosate MA 33.6% formulations would be the best for the post-emergence control of mixed weeds in a mature rubber plantation. *Roundup*, *Asset* and *Ammo Supre*, the commercial glyphosate-herbicides, were used for comparison in both the field Trials 1 and 2 as shown in Table 1 (and Figure 5a) and Table 2 (and Figure 5b).

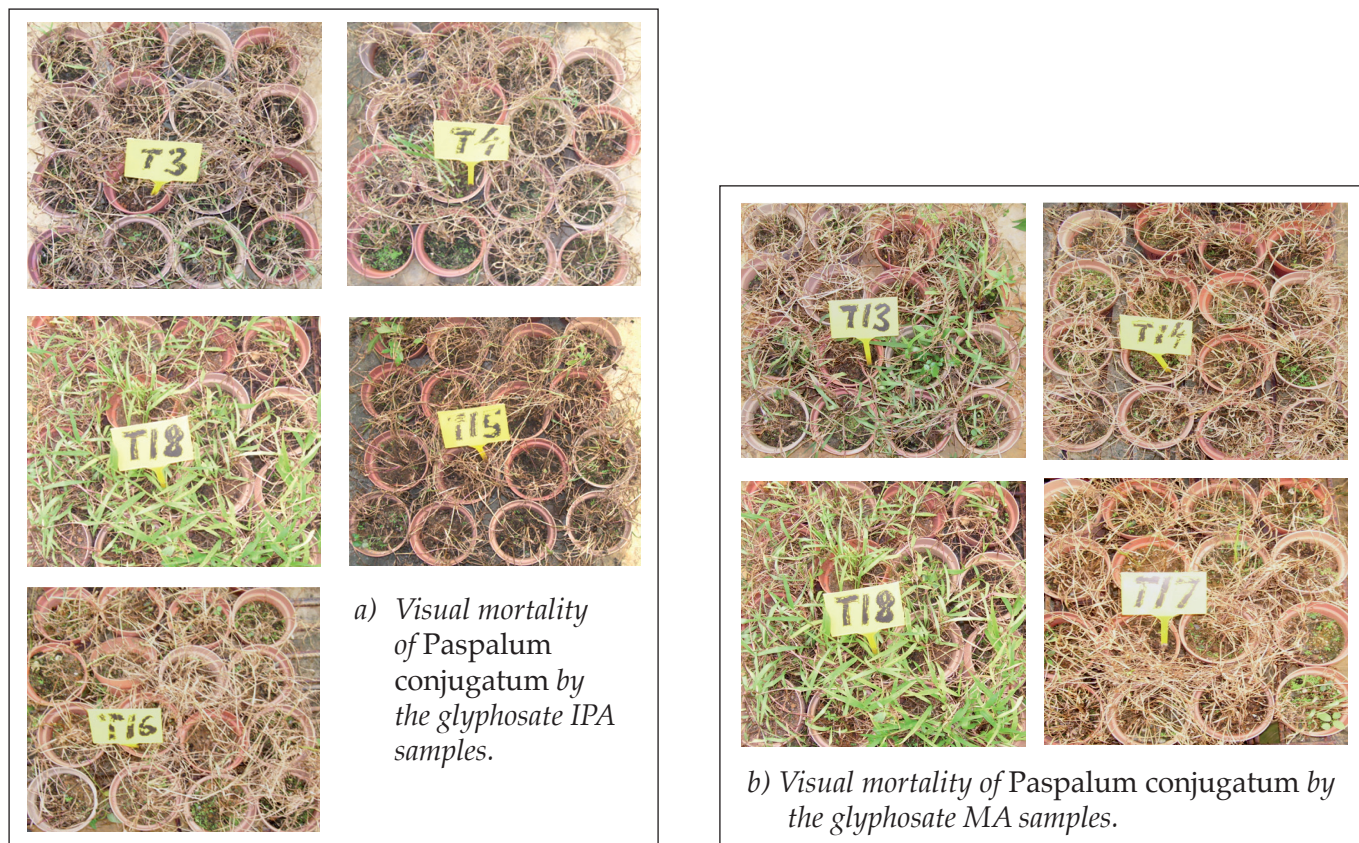


Figure 4. Visual mortality of *Paspalum conjugatum* treated with a) blended palm oil-based adjuvants T3 for MAGPIPA-S3 and T4 for MAGPIPA-S4 in glyphosate IPA, and b) blended palm oil-based adjuvants T13 for MAGPMA-S6 and T14 for MAGPMA-S7 in glyphosate-MA at 14 days after treatment (DAT). The trials were compared to the commercial herbicides Roundup (T15), Asset (T16) and Ammo™ Supre (T17), and a control with untreated weeds (T18).

TABLE 1. BIOEFFICACY OF BLENDED PALM OIL-BASED ADJUVANTS IN GLYPHOSATE IPA (GIPA) 41% ON COMMON WEEDS IN MATURE OIL PALM INTER-ROWS

Treatment	Rate ha ⁻¹ (litres)	Overall % of weed control					
		3DAT*	7DAT	14DAT	21DAT	28DAT	35DAT
MAGPIPA-S3; 7.5%	3	2.7 f	11.0 fg	58.3 e	70.0 g	80.0 f	83.3 f
MAGPIPA-S3; 10%	3	4.3 cd	12.7 e	63.3 c	81.7 cd	91.7 bc	93.3 bc
MAGPIPA-S3; 12.5%	3	4.7 bc	15.0 abc	60.0 d	75.0 f	81.7 ef	85.0f
MAGPIPA-S4; 7.5%	3	3.0 ef	14 c	63.3 c	78.3 e	86.7 d	88.3 e
MAGPIPA-S4; 10%	3	4.3 ab	13.7 cd	68.3 c	85.0 b	93.3 a	95.0 ab
MAGPIPA-S4; 12.5%	3	4.0 de	14.3 bc	73.3 a	86.7 ab	91.7 bc	96.0 a
<i>Asset</i>	3	4.0 de	15abc	70.0 b	85.0 b	90.0 c	93.3 bc
<i>Roundup</i>	3	1.7 g	8.7 h	51.7 f	73.3 e	86.7 d	90.0 de
<i>Ammo Supre</i>	3	3.0 f	10.3 g	63.3 c	80.0 d	90.0 c	91.7cd
<i>Control</i>	-	0 h	0 i	0 g	0 h	0 g	0 g

Note: From statistical analysis (Tukey's Studentized [HSD] test), means followed by the same letter in the same column are not significantly different from one another at p=5%. MAGPIPA-S3 and MAGPIPA-S4 represent the glyphosate IPA 41% (w/w) formulations containing the blended palm oil-based adjuvants S3 and S4, respectively.

*DAT = days after treatment.

TABLE 2. BIOEFFICACY OF GLYPHOSATE MA (GMA) 33.6% ON COMMON WEEDS IN MATURE RUBBER TREE INTERROWS

Treatment	Rate ha ⁻¹ (litres)	Overall % of weed control					
		3DAT	7DAT	14DAT	21DAT	28DAT	35DAT
MAGPMA-S6; 7.5%	3	3.7c	25.0 e	80.0 e	91.7 b	93.0c	94.0c
MAGPMA-S6; 10%	3	4.3 b	28.3 c	83.3 c	91.7 b	93.0c	94.0c
MAGPMA-S6; 12.5%	3	3.7 c	26.7 d	83.3 c	95.0 a	95.0b	96.0b
MAGPMA-S7; 7.5%	3	4.3 b	26.7 d	83.3 c	91.7 b	95.0b	96.0b
MAGPMA-S7; 10%	3	5.0 a	30.0 b	85.0 b	95.0 a	98.0a	99.0a
MAGPMA-S7; 12.5%	3	3.7 c	26.7 d	81.7 d	91.7 b	98.0a	99.0a
Asset	3	3.0 d	25.0 e	85.0 b	91.7 b	95.0b	96.0b
Roundup	3	3.0 d	28.3 c	81.7 d	91.7 b	95.0b	96.0b
Ammo Supre	3	3.0 d	31.7 a	88.3 a	95.0 a	98.0a	99.0a
Control	No treatment	0e	0f	0f	0c	0d	0d

Note: From statistical analysis (Tukey's Studentized [HSD] test), means followed by the same letter in the same column are not significantly different from one another at p=5%. MAGIPA-S6 and MAGPIPA-S7 represent the glyphosate MA 33.6% (w/w) formulations containing the blended palm oil-based adjuvants S6 and S7, respectively. DAT – days after treatment.

CONCLUSION

From the small-scale and field Trials 1 described, it can be concluded that blended palm oil-based adjuvant S4 (MAGPIPA-S4; 10%w/w) in glyphosate IPA 41% was the best formulation that provided the optimum dosage of the blended palm oil-based adjuvant for the control of common weeds in a mature oil palm plantation throughout the assessment period up to 35 days after treatment (DAT). Furthermore, the small-scale and field Trials 2 determined that the blended palm oil-based adjuvant S7 (MAGPMA-S7; 10%w/w) in glyphosate MA 33.6% was the best formulation providing the optimum dosage of the blended palm oil-based adjuvant for the control of common weeds in a mature rubber plantation throughout the assessment period up to 35 DAT. Thus, MPOB and Ancom Crop Care Sdn Bhd have agreed to use these best formulations for commercial production. However, the company has requested that the economics and investment returns for the transferred products not be disclosed in this *Information Series*.



Figure 5. Field bioefficacy of a) blended palm oil-based adjuvant (MAGPIPA-S4; 10%w/w) in glyphosate IPA 41% on common weeds in mature oil palm inter-rows; and b) blended palm oil-based adjuvant (MAGPMA-S7; 10%w/w) in glyphosate MA 33.6% on common weeds in mature rubber tree inter-rows at i) 0 days after treatment (DAT), ii) 14 DAT; and iii) 28 DAT.

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