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Short communication

# Optimizing herbicidal efficacy of glyphosate isopropylamine salt through ammonium sulphate as surfactant in oil palm (*Elaeis guineensis*) plantation in a rainforest area of Nigeria

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**Abstract**

A randomized complete block field trial was conducted over 2 years to evaluate the herbicidal efficacy of glyphosate isopropylamine salt (Roundup®) applied singly at 1.41 kg a.e. $ha^{-1}$ or in combination with ammonium sulphate (AMS) as surfactant at 0.5, 1.0, 1.5, and 2.0% (wt/v) in a 5-year old oil palm plantation of the Federal University of Technology, Akure located in the rainforest vegetation zone of Nigeria. Assessment of herbicidal efficacy based on the Henderson-Tilton formula indicated that glyphosate applied singly or in combination with varying concentrations of AMS proved highly effective in controlling most of the grasses and broadleaved weeds prevalent in the experimental plots. Herbicidal efficacy on total weed density, weed fresh weight as well as on weed dry weight was found to increase in the order of increasing concentration of AMS. Regressing percentage herbicidal efficacy ($Y$) against increasing concentration levels of AMS ($X$) indicated significant ($P \leqslant 0.001$) positive relationships with an average correlation coefficient ($r$) of $+0.95$ in both years. These results confirm the potential of AMS as an effective surfactant that can be exploited in glyphosate-based weed management schemes in the sub-humid tropical environment.



*Keywords:* Weed control; Plantation crop; Roundup; Tropics

## 1. Introduction

Glyphosate is a nonselective herbicide that is formulated as an isopropylamine or trimethylsulfonium salt and used for postemergence control of a cross-section of annual and perennial weeds including *Imperata cylindrica* (spear grass), *Panicum maximum* (Guinea grass) and *Cynodon dactylon* (Bermuda grass). Despite its nonselectivity and systemic activity, some differential tolerance has been reported in *Talinum triangulare* (water leaf), *Cynodon nlemfuensis* (giant star grass) and *Abutilon theophrasti* (common ragweed) (Akobundu, 1987; Jordan et al., 1997). The leaf cuticle and plasma membrane have been identified as barriers limiting glyphosate activity (Denis and Delrot, 1993; Riechers et al., 1994). Neither glyphosate nor its different salts are effective in overcoming these barriers easily without appropriate surfactants (Buhler and Burnside, 1983; Jordan, 1981). Cationic surfactants have been found to be more effective than nonionic surfactants in increasing efficacy (Wyrill and Burnside, 1976; Riechers et al., 1995). The addition of ammonium sulphate (AMS), an inorganic salt, to the glyphosate spray solution improved the efficacy of the herbicide (Blair, 1975).

The present study aimed to optimize the efficacy of glyphosate for weed control using AMS as surfactant at varying concentrations in an oil palm plantation in a sub-humid tropical environment.

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## 2. Materials and methods

The study was conducted at the oil palm plantation of the Teaching and Research Farm of the Federal University of Technology, Akure (7° 16′ N, 5° 12′ E), located in the rain forest vegetation zone of Nigeria, during the late (September–December) and early (April–July) cropping seasons of 2003 and 2004, respectively. The average annual rainfall is about 1300 mm with a mean temperature of 27 °C and the climate is of the sub-humid type. The oil palm plantation was established in 1999 with *tenera* palm seedlings obtained from the Nigerian Institute for Oil Palm Research (NIFOR), Benin-City, Nigeria and planted at the standard spacing of 8.7 m triangular (Opeke, 1982). Table 1 shows the soil pH and nutrient status at 5 cm soil depth at the experimental sites in both years.

The herbicide used was a commercial formulation of glyphosate (Roundup®) containing 360 g $l^{-1}$ of glyphosate in the form of 480 g $l^{-1}$ isopropylamine salt formulated as a water-soluble concentrate (WSC). The experiments consisted of six treatments in both years: (1) a weedy check where no weeding occurred throughout the period of the experiment; (2) glyphosate applied alone at the rate of 1.41 kg a.e. $ha^{-1}$ or in combination with (3) 0.5% ammonium sulphate (AMS)(wt/v); (4) 1% AMS; (5) 1.5% AMS, and (6) 2% AMS. Each treatment was replicated four times in a randomized complete block design on individual plots measuring 12 $m^2$ in area with 1 m alleyway between blocks and 0.5 m between plots. The experiments were set up within the avenues of the palms in both years.

The main weed population in the experimental area in both years comprised both annual broadleaved and grass species, prominent among which were: *Aspilia africana*, *Chromolaena odorata*, *Colocasia esculenta*, *Euphorbia heterophylla, Ipomoea involucrata, T. triangulare*, *Brachiaria deflexa*, *Digitaria horizontalis*, and *Setaria longiseta.*

Preliminary weed assessment was conducted before herbicide application to determine the weed spectrum, density and weight of total as well as individual weed species using three fixed 50 × 50 cm quadrats along a diagonal in each plot, from which weed samples were collected and analyzed for the foregoing parameters. Subsequently, treatments were applied with a knapsack sprayer fitted with Polijet nozzles calibrated to deliver 250 l $ha^{-1}$ of the spray solution at a pressure of 2.5 kg $cm^{-2}$. The broadleaved weeds in the plots were already established plants, while the grasses were up to 15 cm high, when spraying was done. Weed control assessment was carried out six (6) weeks after treatment (WAT) by taking weed samples at three sites along a second diagonal in a 50 × 50 cm fixed quadrat from each plot. Collected weed samples were bulked, separated by species, counted, oven-dried at 80 °C for 48 h, and subsequently weighed.

Percentage herbicidal efficacy on total as well as on individual weed populations including their fresh and dry weights was determined using the Henderson-Tilton formula (Puntener, 1981) based on nonuniform weed infestation in the plots before application. This formula was used because the coincidental fluctuations of the weed counts and weed weights in the plots before herbicide application could increase the deviation of the efficacy values and render the interpretation of the results more difficult. Henderson-Tilton's formula corrects arithmetically the various initial weed infestation numbers without separating sampling errors from the actual differences in infestation (Puntener, 1981). The same formula used for calculating herbicidal efficacy on weed density was adopted for computing efficacies on both weed fresh and weed dry weights. Use of this method to express the effect of a treatment was chosen in preference to the (logarithmic) classification scale recommended by the European Weed Research Council (EWRC) or the linear percentage scale because of its adaptability, objectivity and simplicity under these trial conditions.

Collected data were submitted to an analysis of variance (ANOVA) and the Duncan's multiple range test (DMRT) was used to verify the significant differences among treatment means at the 5% probability level (Little and Hills, 1978). Data on weed density and percentage herbicidal efficacy were normalized prior to ANOVA using the square root and arcsine transformations, respectively. Simple linear correlation and regression analysis between herbicidal efficacy or weed growth parameters ($Y$) and increasing concentration levels of AMS ($X$) was performed with a scientific calculator (Casio *fx-7400G* PLUS).

Table 1
Nutrient status and soil pH of experimental sites before treatment application

| Year | pH | Organic matter (%) | N (%) | P (mg $kg^{-1}$) | K | Mg | Ca |
|---|---|---|---|---|---|---|---|
| | | | | | (mmol kg $soil^{-1}$) | | |
| 2003 | 6.76 | 3.60 | 0.35 | 9.65 | 8.75 | 23.45 | 30.65 |
| 2004 | 6.52 | 3.65 | 0.39 | 10.90 | 9.00 | 24.00 | 48.00 |