

Effect of Demeter Adjuvant (Rizospray Extremo) in Enhancing the Effectiveness of Herbicide Mixtures for Effective Weed Control in a Matured Oil Palm Plantation in Western Ghana

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Abstract

An Adjuvant is an additive chemical that is known to enhance the effectiveness of pesticides like herbicides by helping to improve the absorption of the herbicides by weeds and may eventually help to reduce the dosage of the herbicides used. In the current trial, the adjuvant (Rizospray Extremo) was applied at 3 rates, *i.e.*, 73 ml/ha, 109 ml/ha and 145 ml/ha. The herbicide mixtures used for the trial were glyphosate (glyphader) and triclopyr (garlon) mixtures at 436 ml/ha and 182 ml/ha respectively (60 mls glyphosate + garlon at 25 mls mixed in 15 litres of water). The herbicide control was glyphosate at 436 ml/ha + garlon at 182 ml/ha (with no adjuvant) while one plot was used as the no herbicide control. Weeds on the site include both soft weeds and woodies. Observations on weed mortality were made on weekly basis. Generally, herbicide application (with and without the adjuvant) effectively controlled the soft weeds at the site. Percentage weed growth reduction and herbicide efficacies generally increased with increasing rates of the adjuvant. Highest herbicide efficacy of 96% was obtained by the use of the adjuvant at 145 ml/ha. The treatments differed significantly mostly in their levels of control of the woody weeds at the site with adjuvant application at 145 ml/ha inducing the highest control of woody weeds (herbicide efficacy of 95.7%), while Adjuvant application at 73 ml/ha induced an efficacy of 88.91% on the woodies at the site. Glyphosate plus garlon application (without the use of adjuvant) induced an efficacy of 78.39%. The adjuvant was very effective in controlling weeds with waxy cuticles like the *Thaumatococcus* spp which were not effectively controlled without the use of the adjuvant. The adjuvant (Rizospray Extremo) is therefore recommended for use in herbicide mixtures for spot spraying of woodies or noxious weeds at the site.

Keywords: glyphosate, garlon, adjuvant, extremo, herbicides, oil palm

1. Introductions

The oil palm (*Elaeis guineensis* Jacq.) is the highest oil yielding crop and has the highest oil yield per hectare compared to other oilseed crops. It produces two types of oils, *i.e.*, palm oil and palm kernel oil (Corley & Tinker, 2003). The several uses of Palm oil include uses as edible oils, preparing soups and stews, soaps, margarines, tooth paste, beverages, cosmetics, drugs, cakes etc. Palm oil is used as biodiesel in most countries (Abd El-Khair et al., 2019). On a global scale, Indonesia and Malaysia are the leading producers and exporters of palm oil with Ghana producing about 243,852 mt of crude palm oil annually (Ofosu-Budu & Sarpong, 2013).

Oil palm is cultivated mainly in the forest zone in Ghana due to the suitability of climatic conditions (Gyasi, 1992). The forest belt include the South western part of Ghana where three key oil palm plantations are based as well as several smallholders and outgrowers whose livelihood depends on the palm. Higher fresh fruit bunch (FFB) yields (20 metric tons to 24 metric tons per hectare per year) are obtained in the big plantations, while relatively lower FFB yields of between 3 and 10 metric tons are obtained on small scale farms (Ofosu-Budu & Sarpong, 2013). Key yield limiting factors in Ghana include the erratic rainfall pattern, use of poor planting material by smallholder farmers, low usage of fertilizers by smallholder farmers and high weed infestation in plantations and smallholder farms (Corley & Tinker, 2003).

Weed infestation is one of the major problems in oil palm plantations because it will compete with the palm for basic resources like water and mineral salts resulting in yield losses. Chemical weed management is regarded as a simple, reasonably priced, and highly successful form of weed control in various crops. Herbicide translocation to the target site is a multi-step process that involves several different steps (Travlos et al., 2017). Each herbicide is influenced by its formulation, which can be manipulated to optimize its efficacy. Numerous experiments have provided evidence that different glyphosate salts and adjuvant additives play a crucial role in enhancing the absorption and delivery processes of herbicides (Travlos et al., 2017). Adjuvants, which are chemical additives, are specifically designed to enhance the effectiveness of herbicides by facilitating their absorption into weeds. Furthermore, adjuvants have the potential to reduce the required dosage of herbicides.

Adjuvant additives are either added to the original product formulation or later added during the mixing process in the tank. Types of adjuvants include emulsifiable oils, surfactants, ammonium sulphate and related compounds (Aumatell, 1996). Surfactants are the most often used adjuvants and can trigger herbicide diffusion through the cuticle of plants hence increasing herbicide uptake (Hess et al., 2000). The use of adjuvants may help to improve spray retention on leaf surfaces hence enhancing the coverage of herbicides to improve herbicide targeting efficiency (Stock et al., 2000). Adjuvants are vital in glyphosate retention and absorption by the plant surface. Furthermore, some adjuvants appear to increase the solubility of the herbicide in the wax (Schreiber et al., 1996) and stimulate direct stomata infiltration of the spray solution.

The use of herbicides like glyphosate (glisat and ceresate) and metsulfuron-methyl for effective weed control in Ghana have been documented (Ofosu-Budu et al., 2014a, 2014b; Larbi et al., 2013). The use of surfactants to improve herbicide effectiveness for effective weed control has also been documented in other parts of the world (Aumatell, 1996; Caseley, 1996). Ismail et al. (1998) observed significant control of the *Cyperus rotundus* weed by the application of glyphosate mixed with a surfactant. Also a mixture of a herbicide fluroxypyr and an adjuvant effectively controlled the broad spectrum of weeds at a Socfin plantation (Prabawati & Guntoro, 2022).

However, information on the use of adjuvants in weed control systems in Ghana is scanty, little or no documented data exist on the effect of herbicide-adjuvant mixtures on weed control in oil palm plantations in Ghana.

The objectives of the study were to determine the effect of the adjuvant extremo, in enhancing the effectiveness of the herbicide mixture (glyphosate-garlon mixtures) used in controlling weeds in a matured oil palm plantation in Western Ghana and to determine the optimum level of the adjuvant that would maximize weed control at the site.

2. Methods

2.1 Experimental Site

The experiment was carried out in the rain forest zone of Ghana in an oil palm plantation in South Western Ghana, 175 kilometers northwest of Accra (6°05'N; 0°05'W). The site is located in a region with two seasons of heavy rainfall (bi-modal). 1762 mm of rainfall is averagely recorded annually. Throughout the year, temperatures are often high and consistent. The average monthly temperature is between 25.1 °C and 28.4 °C. The average relative humidity is about 82.5%. Some chemical properties of soil used are as follows: pH (1:1 soil: water) = 4.8, total N 0.14%, Available P = 11.8 mg/kg, Available K = 187.48 mg/kg, Organic carbon = 1.35%, ECEC = 4.66 cmol/kg). Oil palm (D × P) belonging to the Deli × Yanganbi cross was cultivate at the site at a density of 145 palms/ha. The fertilizer regime used in the trial blocks are: NPK (10-10-30) applied at 4.0 kg/palm/year and Muriate of Potash applied at 1.5 kg/palm/year. Correction of high soil acidity was done by applying 3.0 kg/palm/year of Dolomite.

2.2 Treatment and Experimental Design

The treatments used were as follows:

- (1) Zero herbicide/adjuvant application-No herbicide control;
- (2) Glyphosate (60 ml/ha) and garlon at 25 ml/ha (herbicide control);
- (3) Glyphosate (60 ml/ha) + garlon (25 ml/ha) + Extremo at 73 ml/ha;
- (4) Glyphosate (60 ml/ha) + garlon (25 ml/ha) + Extremo at 109 ml/ha;
- (5) Glyphosate (60 ml/ha) + garlon (25 ml/ha) + Extremo at 145 ml/ha.

Twenty experimental plot size (5 m × 21 m) were set up using the randomized complete block design. 4 replications were used.

2.3 Spray Calibration

A CP 15 knapsack sprayer (Brand Guarany) fitted with AN 2.5 deflector nozzle was used to deliver 200L/ha of herbicide solution. A 100 m spray length is covered in 1 minutes 40 seconds. Spray calibration was conducted to determine forward speed, spray width (swath), flow rate and application rate as described by Turner and Gillbanks (2003).

2.4 Initial Vegetation Analysis

Weed identification at the site was carried out at the start of the trial. Weeds were identified with their common and scientific names. Weeds were further classified as either soft or woody weeds. Weeds were sampled using a square quadrant with dimensions 0.5 m × 0.5 m. The quadrant sampling was done on weekly basis to determine the relative abundance and the dry weights of the sampled weeds. The different weed species are counted to determine the abundance or density of each species. Drying of weeds was done first by sun drying for 4 days before drying in the Memmert oven for 12 hours at 80 °C (Felix & Owen, 1999). The formula for the determination of Relative abundance or dominance as spelt out by Derksen et al. (1993) is stated as follows:

$$\text{Relative (X) of a species} = \frac{\text{Absolute (X) of the species}}{\text{Total absolute (X) of all species}} \quad (1)$$

where, X = density or dominance.

2.5 Effects of Herbicide-Adjuvant Mixtures on Weed Population

Weed mortality was observed after herbicide application hence a progressive reduction in weed dry weights were observed after spraying. Percentage weed mortality at weekly intervals after spraying was determined and used to estimate the percentages weed growth reduction and percentage herbicide efficacy.

The percent growth reduction is expressed as the ability of the herbicide treatment to suppress weed growth. It was determined mathematically as spelt out by Chuah et al. (2004) as follows:

$$\% \text{ Growth Reduction} = \frac{\text{Dry weight from treated plot}}{\text{Dry weight from untreated plot}} \times 100 \quad (2)$$

The herbicide/adjuvant mixture efficacy is expressed as the power or capacity to produce the desired effect of effective weed control. The herbicide (herbicide-adjuvant mixture) efficacy (E) of herbicide by mass of weeds was calculated by the following formula:

$$E = \frac{M1 - M2}{M1} \times 100 \quad (3)$$

where, M1 = Mass of weeds on the untreated plot; M2 = Mass of weeds on treated plots treated with herbicides (Auskalnis, 2003).

Analysis of variance (ANOVA) was conducted to test the treatment effects. The mean separation was done at 5% significance level. The statistical softwares used for the analysis were: GenStat and R-studio. Microsoft Excel was also used for some statistical estimations.

3. Results

3.1 Initial Vegetation Analysis

Data on predominant weeds at the experimental site are presented in Table 1. The weed population at the site consisted of a mixture of woodies and soft weeds. The soft broad-leaved weeds at the experimental site include: *Pueraria phaseoloides*, *Ageratum conyzoides*, *Thaumatococcus daniellii*, *Laportea aestuans*, *Vandasina retusa*, *Nephrolepis biserrata*, *Panicum lineatum* and *Cynodon dactylon*. Woody weeds at the site include: *Griffonia simplicifolia*, *Chamaecostus cuspidatus*, *Heinsia crinita*, *Finlaysonia obovata* and *Pterisanthes* spp. The weed configuration comprised of 8 soft weeds and 6 woody weed species. Most of the broad leaves were woody in nature. Woody weeds (67.50%) were the most dominant species followed by soft weeds (32.49%). The Finlayson creeper was the most dominant species at the site with relative dominance of 24.38% followed by the *Griffonia simplicifolia* with 18.21% and *Heinsia crinita* 16.53%. The least dominant species was the *Diplazium esculentum* with 0.16%. In terms of relative abundance, *Nephrolepis biserrata* was the most abundant species with 34.39% followed by *Griffonia simplicifolia* with 12.74% and *Thaumatococcus daniellii*, 8.28%. The least abundant species was the *Heinsia crinita* with 1.27%.

Table 1. Predominant weeds at the experimental site at the start of the trial

Species	Common name	Type	Relative dominance (%)	Relative abundance (%)
<i>Laportea aestuans</i>	West Indian Nettle.	S	3.29 (e)	3.18 (b)
<i>Pueraria phaseoloides</i>	Cover Crop	S	3.13 (d)	3.82 (c)
<i>Thaumatococcus daniellii</i>	Sweet Prayer Plant	S	0.57 (b)	8.28 (g)
<i>Vandasina retusa</i>	Amumuha	W	0.70 (b)	3.82 (c)
<i>Nephrolepis biserrata</i>	Giant Sword Fern	S	11.98 (j)	34.39 (i)
<i>Ageratum conyzoides</i>	Billy goat-weed	S	1.88 (c)	3.82 (c)
<i>Griffonia simplicifolia</i>	Griffonia	W	18.21 (l)	12.74 (h)
<i>Panicum lineatum</i>	Corn grass	S	7.30 (i)	3.18 (b)
<i>Chamaecostus cuspidatus</i>	Fiery costus	W	4.59 (h)	4.46 (d)
<i>Heinsia crinita</i>	Bush apple	W	16.53 (k)	1.27 (a)
<i>Finlaysonia obovata</i>	Finlayson creeper	W	24.38 (m)	7.64 (f)
<i>Diplazium esculentum</i>	Fiddlehead fern	S	0.16 (a)	4.46 (d)
<i>Cynodon dactylon</i>	Bermuda grass	S	3.48 (f)	5.10 (e)
<i>Pterisanthes spp</i>	Eriopoda	W	3.79 (g)	3.82 (c)
Total			99.99	100
LSD ($P \leq 0.05$)			0.138	0.0595

Note. S: soft weeds, W: woody weeds.

3.2 Effect of Herbicide-Adjuvant Mixtures on Weed Dry Weights and Weed Growth Reduction

Application of adjuvant (extremo) at all doses reduced the dry weights of weed species under each treatment significantly at 2, 4 and 6 weeks after treatment (WAT) compared to the untreated plot (Table 2). Weeds were sampled at weekly intervals with a quadrant and the dry weights determined. Dry weights decreased gradually from the first week of spraying till final senescence. At 6 weeks after treatment, the combined application of the herbicide mixture with the adjuvants applied at the 2 rates, 145 ml/ha and 109 ml/ha resulted in more than sixty-fold reduction in weed dry weights compared to the untreated plot. Application of adjuvant at 73 ml/ha induced a thirty-fold reduction in weed dry weight compared to the control while application of the herbicide mixture alone resulted in a twelve-fold decrease in weed dry weight. Percentage weed growth reduction was determined as the ratio of weed dry weight on the untreated plot to that of the treated plot. Percent growth reduction increased with increasing rate of adjuvant application and also increased from the second week to the sixth week after treatment. At all the weeks after treatment, percent growth reduction increased in the order: Untreated plot < GG only < GGE at 73 ml/ha < GGE at 109 ml/ha < GGE at 145 ml/ha. At 6 weeks after treatment, percent growth reduction recorded by the combined herbicide and adjuvant application at rates 73 ml/ha, 109 ml/ha and 145 ml/ha exceeded the percent growth reduction recorded in the glyphosate plus garlon alone treatment by 3%, 7% and 9% respectively. Highest percent growth reduction was observed in the combined herbicide plus adjuvant application at 145 ml/ha.

Table 2. Weed dry weights and percent weed growth reduction after treatment with herbicides and adjuvant

Treatment	Dried Weight (g)			Growth Reduction (%)		
	2 WAT	4 WAT	6 WAT	2 WAT	4 WAT	6 WAT
Untreated Plot	366.12(e)	370.41(e)	373.12(e)	0(a)	0(a)	0(a)
GG only	103.93(d)	87.34(d)	30.41(d)	71.61(b)	80.42(b)	88.81(b)
GGE at 73 ml/ha	59.76(c)	38.78(c)	18.23(c)	83.68(c)	89.53(c)	92.11(c)
GGE at 109 ml/ha	39.57(b)	18.16(b)	6.05(b)	89.19(d)	95.10(d)	95.38(d)
GGE at 145 ml/ha	33.14(a)	12.42(a)	5.81(a)	90.95(e)	95.65(e)	96.44(e)
LSD	0.2247	0.1292	0.0958	0.03497	0.0928	0.0835

3.3 Effect of Herbicide-Adjuvant Mixtures on Percent Herbicide Efficacy

Data on percent herbicide efficacies obtained by the application of glyphosate (glyphader) and adjuvant extremo are presented in Table 3. Herbicide efficacies increased with increasing adjuvant rates. Herbicide efficacies also

increased from the second week after treatment to the sixth week after treatment. Adjuvant application generally induced higher herbicide efficacies on the woody weeds at the site compared to the no herbicide mixtures. However in the case of the soft weeds, the differences in herbicide efficacies between the combined herbicide plus adjuvant and the herbicide alone treatment were not very high. For example in the 4th week after treatment, no significant difference in herbicide efficacy was observed for soft weeds between the herbicide alone (glyphosate plus garlon alone) treatment and the combined herbicide plus adjuvant application at 73 ml/ha. At 6 weeks after treatment, herbicide efficacies recorded by the combined herbicide and adjuvant application at rates 73 ml/ha, 109 ml/ha and 145 ml/ha exceeded the herbicide efficacy recorded in the glyphosate plus garlon alone treatment by 0.3%, 2% and 3% respectively for the soft weeds. In the case of woody weeds, herbicide efficacy recorded by the combined herbicide and adjuvant application at rates 73 ml/ha, 109 ml/ha and 145 ml/ha exceeded the herbicide efficacy recorded in the glyphosate plus garlon alone treatment by 16%, 18% and 22% respectively. Highest percent herbicide efficacy was observed in the combined herbicide plus adjuvant application at 145 ml/ha.

Table 3. Percent herbicide efficacy after application of herbicide at 2, 4 and 6 weeks after treatment

Treatments	Herbicide efficacy (%)					
	2 WAT		4 WAT		6 WAT	
	Soft	Woody	Soft	Woody	Soft	Wood
Untreated plot	0(a)	0(a)	0(a)	0(a)	0(a)	0(a)
GG (control)	67.82(b)	26.74(b)	90.22(b)	60.38(b)	93.28(b)	78.39(b)
GGE at 73ml/ha	76.81(c)	52.15(c)	91.27(b)	78.10(c)	93.55(c)	90.71(c)
GGE at 109ml/ha	74.37(d)	57.74(d)	94.35(c)	84.78(d)	95.14(d)	92.37(d)
GGE at 145ml/ha	81.79(e)	59.89(e)	95.65(d)	89.10(e)	96.50(e)	95.70(e)
LSD	0.04631	0.1070	0.0977	0.0910	0.1841	0.1457

Note. NB: GG: Glyphosate (60 ml/ha) + Garlon (at 25 ml/ha);

GGE at 73 ml/ha: Glyphosate (60 ml/ha) + Garlon (at 25 ml/ha) + Extremo (Adjuvant) at 73 ml/ha;

GGE at 109 ml/ha: Glyphosate (60 ml/ha) + Garlon (at 25 ml/ha) + Extremo (Adjuvant) at 109 ml/ha;

GGE at 145 ml/ha: Glyphosate (60 ml/ha) + Garlon (at 25 ml/ha) + Extremo (Adjuvant) at 145 ml/ha.

4. Discussion

Weed infestation in oil palm is a key yield limiting factor due to weeds competing with the palms for common resources like water and mineral salts. The weeds at the experimental site consisted of both hard and soft weeds similar to observations made at other oil palm plantations (Essandoh et al., 2011). Similar weeds under oil palm were reported by Ofosu-Budu et al. (2014a). The dominance of woody weeds at the site (67.50%) requires the use of herbicides like triclopyr (garlon) for effective weed control. Some weeds at the site like the *Thaumatococcus daniellii* and *Heinsia crinita* have leaves with waxy cuticular surfaces and hence have poor contact with herbicide droplets. The use of adjuvants may enhance the penetration of herbicides into the leaves (Prabawati & Guntoro, 2018). The tropical fern, *Nephrolepis biserrata* was the most abundant species (relative abundance 34.39%) at the site and is commonly associated with oil palm acting as a soil cover. Leguminous cover crops are however preferred to the ferns. The leguminous cover crop, *Pueraria phaseoloides* is sprayed within the palm circles at specific time intervals to prevent it from spreading to cover the palms. The weed composition at the site calls for the use of pre and post-emergent herbicides with possible combinations with adjuvants for effective weed control at the site (Mohamad et al., 2010).

Application of adjuvant (extremo) at all doses reduced the dry weights of weed species significantly at 2, 4 and 6 weeks after treatment, indicating the effectiveness of the herbicide treatments in reducing the population of the weeds compared to the untreated plot. Results from the current study compares favorably to the findings of other authors (Prabawati & Guntoro, 2022; Larbi et al., 2013; Ismail et al., 1998). Traore et al. (2010) observed significant reduction in weed dry weights by the application of different adjuvant mixtures. Ofosu-Budu et al. (2014a), observed similar reductions in weed dry weights at 2, 4 and 8 weeks after treatment, by the application of glyphosate (glisat) at levels: 0.8 L/ha, 1.4 L/ha, 2.8 L/ha and 4.3 L/ha. Glyphosate (glisat) application at 4.3 L/ha induced highest effects on percent growth reduction and herbicide efficacy, similar to the current results. In the current study, the combined application of herbicide plus adjuvant application at 145 mls/ha induced highest

effects on herbicide efficacy and percent growth reduction. Other studies by Ofosu-Budu et al. (2014b), revealed significant reduction in weed dry weights by the combined application of metsulfuron—methyl and glyphosate (glisat).

The adjuvant (extremo) used in the current study exerted higher effects on the woody weeds at the site as compared to the no adjuvant application (herbicide alone). Weeds like the *Heinsia crinita* and *Thaumatococcus* species were effectively controlled by the adjuvant. Such weeds were difficult to control with the herbicide mixture alone due to the waxy cuticular surfaces of their leaves. Adjuvants are known to work in several ways and act as penetrants, wetting agents, spreaders, co-solvents, stickers and stabilizing agents (Aumatell, 1996). Mixing herbicides with adjuvants like extremo can help in controlling the broad spectrum of weeds in oil palm plantations.

5. Conclusions

Results of the current study revealed that the use of glyphosate-garlon mixtures (with or without the extremo adjuvant) reduced weed growth significantly compared to the no herbicide control. However, the combination of herbicides+ adjuvant was the most effective in controlling hard or woody weeds at the site. Herbicide efficacy among the treatments at 6 WAT was ranked as follows; Glyphosate + garlon + extremo at 145 ml/ha > Glyphosate + garlon+ extremo at 109 ml/ha > Glyphosate + garlon + extremo at 73 ml/ha > Glyphosate +garlon only > No herbicide control. At the same rate of herbicide application, weed mortality was higher by the use of the adjuvant than without the adjuvant even though the general soft weeds and some selected hard weeds were generally effectively controlled even without the adjuvant. Higher dosages of Adjuvant (Extremo) significantly increased herbicide efficiency. Glyphosate + garlon + extremo at 145 ml/ha may therefore be recommended for effective control of both hard and soft weeds at the experimental site.

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