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Effect of Adjuvant on the Rainfastness and Herbicidal Activity of Glyphosate Against *Cynodon dactylon* and *Cyperus rotundus* Weeds

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Abstract

Glyphosate is a highly effective nonselective post emergence herbicide useful for combating the presence of a wide variety of unwanted vegetation including agricultural weeds. Glyphosate in ionic form has relatively higher water solubility, especially when formulated as salt, and during the uptake period immediately after application glyphosate is vulnerable to being washed off the foliage by rain or by overhead watering or irrigation. Field experiments were conducted to examine the effect of adjuvant on the rainfastness of glyphosate against *Cynodon dactylon* and *Cyperus rotundus* weeds. The effect of rain and adjuvants were determined by % weed control after treatment given to the treated weeds. The 20 mm rainfall with interval of 2 and 4h after treatment washed off entire glyphosate from the foliage and resulting poor weed control (15%). With the addition of surfactant to glyphosate, helped in absorbing glyphosate as quickly as 2 h after treatment and improving the rainfastness or % control of *C. dactylon* and *C. rotundus* weeds under different simulated rainfall with different intervals.

Key words: *Cynodon dactylon, Cyperus rotundus* , Adjutants, Rainfastness

Introduction

Glyphosate is a highly effective nonselective post emergence herbicide useful for combating the presence of a wide variety of unwanted vegetation including agricultural weeds. Glyphosate in ionic form has relatively higher water solubility, especially when formulated as salt, and during the uptake period immediately after application glyphosate is vulnerable to being washed off the foliage by rain or by overhead watering or irrigation. Adjuvants are commonly applied with pesticides to improve spray performance characteristics such as coverage and absorption (Thompson et al., 1996), persistence on foliage (Reddy and Locke 1996), and efficacy (Hunsche et al., 2007). Independent of the type of pesticide applied, maximum deposition of the active ingredient on the target surface is a prerequisite for achieving optimum biological efficacy. Adjuvants may contribute significantly. Some are very effective in promoting wetting and spreading and preventing droplets from run-off or insufficient adhesion due to rebound. The impact of rain may induce significant losses of active ingredient. It has been documented by several studies that addition of adjuvants may improve rainfastness and biological efficacy of herbicides (Combellack et al., 2001 and Hunsche et al., 2007). The impact of rain on deposition manifests itself on various occasions depending on droplet size, intensity, kinetic energy, total volume, and the duration of exposure. The chemical properties of the active ingredient itself play important in biological efficacy of the herbicide. Hydrophilic active ingredients are more sensitive to wash-off by rain than others. Due to the low solubility in water (~ 1.2% at 25°C), glyphosate is applied as the isopropylamine salt. As a result of this the higher water solubility leads to increased vulnerability to wash-off by rainfall (Caseley et al., 1976; Bryson 1987; Bryson1988). The wide range of available adjuvants offers a possibility to overcome this critical aspect of toxicant bioavailability; selection of appropriate adjuvants can improve rainfastness of such chemicals (Combellack et al., 2001). The objective of this study was to investigate the influence of adjuvant on the biological efficacy of glyphosate under different simulated rainfall with different intervals. The adjuvant solutions were applied on two weed species i.e., *Cynodon dactylon* and *Cyperus rotundus* . The biological efficacy of glyphosate on rain-exposed weed plants were calculated on the basis of weed plants mortality.

Materials and Methods

Plant material

Field experiment was conducted during the winter season in 2002and 2003 at experimental research farm of Institute of Pesticide Formulation Technology, Gurgaon, India. Two weed species, *Cynodon dactylon* and *Cyperus rotundus* were grown in the pots filled with a dampened mixture of topsoil and farm yard manure. The

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plants were watered every day and no pesticide was applied during the growth period. Temperature and humidity were maintained before and after treatment application and rain simulation, respectively.

Treatment solutions

The post emergence herbicide treatments comprised Glyphosate @ 10ml L^{-1} of water (without surfactant), with 0.10 % surfactant (supplied by Excel Industries Ltd), 0.10 % surfactant (supplied by IPFT) including gum along with untreated control.

Application of spray solution

Rainfall was simulated using four 1/4G10 solid cone nozzles 80cm apart on a square frame. The 1/4G10 nozzles were selected as it produces a droplet spectrum resembling natural rainfall (Simmons, 1980). This arrangement of nozzles provided a target area of approximately 1.5m 2 on the ground. Water was supplied directly from the mains through a pressure regulating valve which was adjusted to give a constant working pressure of 70 kPa. As the delivery rate from the nozzle was much higher than that of the equivalent rainfall, and it was not possible to reduce the intensity by lowering the supply pressure without changing the droplet-size distribution, it was necessary to intercept a proportion of the nozzle output using aluminium 'V' channels. The lowest intensity was achieved when all the 'V' channels were in place, but by removing and replacing channels, the intensity of the simulated rainfall could be altered. The nozzle was fitted approximately 4 m above the ground to allow the drops to reach their terminal velocity. Two intensities of rainfall were chosen, namely 5 mm/h and 20 mm/h. Rainfall was simulated using tap water 2 h and 4 h after application of spray solutions. Two levels of rain intensity and a reference (no rain) treatment were used. Immediately after stopping rain simulation plants were transferred back to the greenhouse. For all treatments, the mean of four replicates of each treatment was calculated with its standard error, and a two-way analysis of variance carried out. A least significant difference test was used to compare individual means.

Results and Discussion

Effect on Weeds mortality

In *Cynodon. dactylon* the application of glyphosate spray solutions always gave 100% mortality 30 days after spraying in the absence of rainfall in comparison to the water control when plants were not exposed to rain (table 1). Rainfall intensity had a highly significant effect on the efficacy of the adjuvants against *Cynodon dactylon* weed control at 15 and 30 days after spraying. The addition of 0.10% surfactant to the glyphosate in tank mixed increased the % mortality of the weed even after simulation of high intensity rain fall 20 mm with intervals of 2h and 4h after treatment. With the addition of surfactant to glyphosate, helped in absorbing glyphosate as quickly as 2 h after treatment and improving the rainfastness or % control of *C. dactylon weed*.

In *C. rotundus the* application of glyphosate spray solutions always gave 98% mortality 30 days after spraying in the absence of rainfall in comparison to the water control when plants were not exposed to rain (table 2). Rainfall intensity had a highly significant effect on the efficacy of the adjuvants against *C. rotundus* weed control at 15 and 30 days after spraying. The addition of 0.10% surfactant to the glyphosate in tank mixed increased the % mortality of the weed even after simulation of high intensity rain fall 20 mm with intervals of 2h and 4h after treatment. The 20mm rainfall with interval of 2 h and 4 h after treatment washed off entire glyphosate from the foliage resulting poor weed control (15%) of *C. rotundus(table 2)*. With the addition of surfactant to glyphosate, helped in absorbing glyphosate as quickly as 2 h after treatment and improving the rainfastness or % control of *C. dactylon* and *C. rotundus* weeds. The addition of 0.10% surfactant to the glyphosate in tank mixed Significantly reduced glyphsate washoff from the foliage. A high bio-performance of glyphosate indicates that the a.i. has effectively passed through the cuticle and penetrated the leaf tissue. Penetration rate depends mainly on characteristics of the spray solution, physicochemical properties of leaf surfaces, environmental conditions, and interactions between all factors. Addition ethoxylates adjuvant intended primarily to enhance pesticide deposition and penetration before the rain event, but also to minimize the rain-induced wash-off, enabling a.i. penetration even after rain (Singh and Singh 1995. Scherhah 2005 and Hunsche et al., 2007).

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Table 1: Influence of simulated rains on the efficacy of Glyphosate with and without adjuvants against *Cynodon dactylon* weed.

Name of formulation	Dose (ml/L)	Surfactant (conc %)	Per cent mortality*									
			15 days after spraying					30 days after spraying				
			With rain				Without rain	With rain				Without rain
			Rain intervals					Rain intervals				
			2 h		4 h			2 h		4 h		
			Rain intensity		Rain intensity			Rain intensity		Rain intensity		
			5mm	20mm	5mm	20mm		5mm	20mm	5mm	20mm	
Glyphosate	10.0	-	40.33	25.33	40.33	30.33	74.67	85.0	80.33	88.00	80.33	95.00
Glyphosate + excel surfactant	10.0	0.10	79.67	75.33	79.67	74.67	85.00	98.00	94.67	98.00	95.33	100.00
Glyphosate + IPFT surfactant	10.0	0.10	70.00	50.00	80.00	64.67	85.00	98.33	90.33	98.00	95.33	100.00
Glyphosate + excel surfactant + Gum	10.00	0.10 + 0.10	60.33	54.67	84.67	75.33	85.33	95..3	90.33	98.00	94.67	100.0
Glyphosate + IPFT surfactant + Gum	10.0	0.10 + 0.10	79.67	74.67	85.00	70.33	90.00	98.00	94.67	97.67	95.00	100.00
Glyphosate + Gum	10.0	0.10	34.67	20.00	35.33	20.33	75.00	84.67	80.33	85.33	80.00	95.00
c.d. at 5%			8.11	6.04	5.50	7.71	10.86	6.64	6.60	5.11	9.34	5.32

*mean of two experiments

Table 2: Influence of simulated rains on the efficacy of Glyphosate with and without adjuvants against *Cyperus rotundus* weed.

Name of formulation	Dose (ml/L)	Surfactant (conc %)	Per cent mortality*									
			15 days after spraying					30 days after spraying				
			With rain				Without rain	With rain				Without rain
			Rain intervals					Rain intervals				
			2 h		4 h			2 h		4 h		
			Rain intensity		Rain intensity			Rain intensity		Rain intensity		
			5mm	20mm	5mm	20mm		5mm	20mm	5mm	20mm	
Glyphosate	10.0	-	24.00	15.00	25.00	15.33	69.67	84.67	79.67	85.00	80.33	98.00
Glyphosate + excel surfactant	10.0	0.10	59.67	50.00	65.33	55.67	75.00	85..3	80.33	90.33	84.67	98.33
Glyphosate + IPFT surfactant	10.0	0.10	70.00	50.33	75.00	59.67	85.33	93.67	84.67	91.67	84.33	98.00
Glyphosate + excel surfactant + Gum	10.00	0.10 + 0.10	54.67	35.33	65.00	54.67	84.67	90.33	85.00	89.67	85.00	98.00
Glyphosate + IPFT surfactant + Gum	10.0	0.10 + 0.10	69.67	50.33	74.00	60.67	75.67	85.00	80.33	84.67	79.67	99.00
Glyphosate + Gum	10.0	0.10	45.00	25.33	45.33	25.33	70.67	84.67	80.00	85.33	79.67	99.00
c.d. at 5%			6.70	4.01	4.62	6.69	6.22	6.73	7.33	7.42	5.82	4.09

*mean of two experiments