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Effect of herbicides associated with adjuvants in surface tension and contact angle in leaves of *Ipomoea hederifolia*

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Abstract

Scarlet Morning Glory is considered to be an infesting weed that affects several crops and causes serious damage. The application of chemical herbicides, which is the primary control method, requires a broad knowledge of the various characteristics of the solution and application technology for a more efficient phytosanitary treatment. Therefore, the present study aimed to assess the combinations of herbicides with adjuvants in their influence at surface tension and contact angle in leaves of Scarlet Morning Glory and a standard surface (glass). This experiment was carried out at Department of Crop Protection of São Paulo State University-UNESP, Campus Jaboticabal-SP, Brazil, during November to December of 2011. Two adjuvants (vegetable oil and mixture tributyl citrate + polydimethylsiloxane), two herbicides (paraquat and glyphosate), water (control), one spraying volume (70 L ha^{-1}) were used for the treatments. All of the solutions exhibited a surface tension significantly lower than the water (control). The solutions with paraquat (with or without adjuvants) exhibited the lowest values for surface tension without significant differences among them at tree times evaluated. As for the contact angle, the treatment and time factors were significant. All solutions resulted in lower values compared with the water (control), except for the glyphosate + tributyl citrate + polydimethylsiloxane treatment on the standard surface (glass) and the glyphosate treatment on the *I. hederifolia* leaf. These results imply that a greater spreading factor on the surface due to lower surface tension can result in a greater spreading of the droplets and therefore the possibility of reduction of the spraying liquid.

Key words: Application technology, Scarlet Morning Glory, glyphosate, paraquat.

Introdution

The genus *Ipomoea,* which is commonly known as Scarlet Morning Glory, is the most prominent in the family Convolvulaceae with over 600 species worldwide. *Ipomea hederifolia* is a plant native to the tropical and subtropical American continent and is considered to be an infesting weed of several crops, hampering the harvest and causing damage to sugar cane, maize and soybeans among other crops (Kissmann & Groth, 1999).

Chemical control is the most commonly used weed management method, and knowledge of efficient herbicides, equipment and appropriate environmental conditions are required. Therefore, the proper application of the phytosanitary product should be performed at the right time, providing sufficient coverage of the target (Ferreira *et al*., 2009) and depositing the required amount of active ingredient to safely eliminate or mitigate a particular problem while aiming to avoid economic and environmental damage (Matuo, 1990).

The activity of the herbicide is often enhanced by adjuvants. The absorption of a herbicide can also be increased by adding one or more adjuvants (Dan *et al*., 2009; Martins *et al*., 2009, Maciel *et al*., 2011), which can reduce the herbicide dose by more than 50% compared with that used without adjuvants (Vargas & Roman, 2006). According Cunha *et al*. (2010) there is little scientific information on this subject, difficulting the selection or recommendation of adjuvants.

The effect of adjuvants on the physicochemical characteristics of aqueous solutions may depend on their chemical composition and formulation. The pH, surface tension and viscosity were the proprieties most sensitive to the addition of adjuvants to the tested solutions (Cunha & Alves, 2009). Therefore this paper aimed to characterize the effect of adjuvantes associated with herbicides on surface tension and contact angle on leafs of *I. hederifolia.*

Material and Methods

The experiments occurred at Department of Crop Protection of Univ of São Paulo State-UNESP, Campus Jaboticabal-SP, Brazil, during November to December of 2011. Two adjuvants, two herbicides, water (control) and one spraying volume (70 L ha^{-1}), were used for the treatments.

The treatments (T) were as follows: T1: water (control); T2: glyphosate (Roundup Original® - 2.5 L ha^{-1}); T3: glyphosate + tributyl citrate + polydimethylsiloxane (Vertex premium®- 0.015 L in 100 L of water); T4: glyphosate + vegetable oil (VegetOil®- 0.2 L in 100 L of water); T5: paraquat (Gramoxone 200®- 1.5 L ha^{-1}); T6: paraquat + tributyl citrate + polydimethylsiloxane; T7: paraquat + vegetable oil.

Surface tension and contact angle of the leaves

Assessments of surface tension were performed using the same treatments (T1 to T7) described above. The leaves used in the assays were collected in the experimental fields. To ensure that the leaves exhibited no rugosity that could compromise the assays, the leaves of *I. hederifolia* were placed in a device specific for this purpose. The surface tension and contact angle assessments were performed using a OCA-15EC goniometer (DataPhysics, Germany), where the surface tension was determined using the pendant drop technique, and droplet spreading was assessed by measuring the contact angle of the droplet with the surface where it was deposited. The image of the liquid droplet, formed in a syringe to the optical thermostat, was captured using a CCD (charge-coupled device) camera, which analyzes the shape of the droplet by axisymmetric drop shape analysis (ADSA). An optical glass cuvette with water in the bottom was used to avoid droplet evaporation. Specific software, which uses an ideal position as the reference line in the image field, was used to identify the key point for starting to record images, even before the complete formation of the droplet. Surface tension was determined through digitization and analysis of the droplet profile using the Young-Laplace equation for fitting. The resulting data of surface tensions and contact angles were subjected to analysis of variance using the F test, and the means were compared using the Tukey test at 5% probability.

Results

Surface tension

All of the solutions exhibited a surface tension significantly lower than the water (control) at 1, 90 and 180 seconds. The solutions with paraquat (with or without adjuvants) exhibited the lowest values for surface tension without significant differences among them at tree times evaluated (Fig. 1).

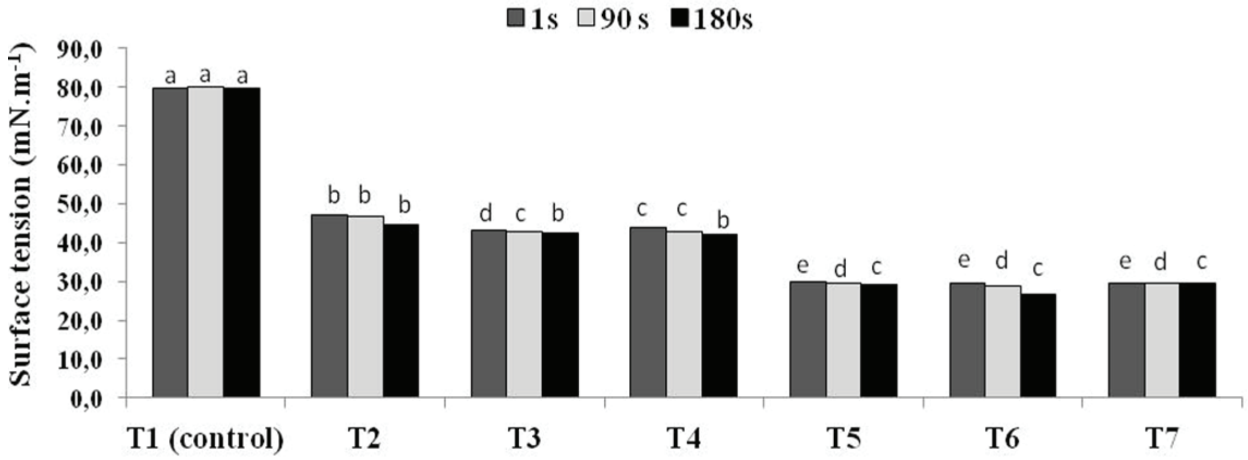

Fig. 1. Values of surface tension of water (control), herbicides and adjuvants used for the control of *Ipomoea hederifolia* in three times evaluated by the pedant drop method. Jaboticabal, SP, 2011.

Contact angle on the leaves of Ipomoea hederifolia

As for the contact angle, the treatment and time factors were significant. All solutions resulted in lower values compared with the water (control), except for the glyphosate + tributyl citrate + polydimethylsiloxane treatment on the standard surface (glass) and the glyphosate treatment on the *I. hederifolia* leaf.

Table 1. *Values of contact angle formed by droplets of aqueous solution containing herbicides and adjuvants on standard surface (glass) and leaf of Ipomoea hederifolia at two moments of evaluation and their interactions. Jaboticabal, SP, 2011*

	Values of contact angle (in degrees)	
Treatment (T)	Glass	Leaf
Water (control)	21.35 b	65.73 a
Glyphosate	26.73 a	54.56 ab
Glyphosate+tributyl citrate + polydimethylsiloxane	19.93 bc	43.91 bc
Glyphosate+ vegetable oil	24.45 a	42.36 bcd
Paraquat	17.64 cd	32.39 cd
Paraquat+tributyl citrate + polydimethylsiloxane	15.73 de	25.66 d
Paraquat+ vegetable oil	14.33 e	26.90 d
F (T)	57.15**	14.55**
Time (Te)		
5 s	24.62 a	50.07 a
60 s	15.42 b	33.24 b

Means followed by the same letter in the same column do not differ from one another by the Tukey test. [NS] Not significant; ** P<0.01.

The lowest contact angle values were observed for the paraquat treatment, regardless of the adjuvant addition. A significant difference was observed for the paraquat + vegetable oil treatment, which was the lowest value obtained among the treatments compared with the water (control) (Table 1).

Table 2. *Breakdown of the interaction of treatments compared with time for the assessment on glass surface (standard) for contact angles of droplets of aqueous solutions containing herbicides and adjuvants. Jaboticabal, SP, 2011*

	Values of contact angle Θ		
Treatment	5 s	60 s	F (T)
Water (control)	24.96 bcA	17.73 bB	36.66**
Glyphosate	28.56 abA	24.86 aB	9.55**
Glyphosate + tributyl citrate + polydimethylsiloxane	24.10 cdA	15.75 bB	48.63**
Glyphosate + vegetable oil	30.90 aA	18.00 bB	116.06**
Paraquat	24.33 cA	10.95 cB	124.76**
Paraquat + tributyl citrate + polydimethylsiloxane	20.45 deA	11.00 cB	62.28**
Paraquat+vegetable oil	19.03 eA	09.63 cB	61.63**
F (C)	24.24**	40.58**	-

Means followed by the same upper case letter in the same row and lower case letter in the same column do not differ from one another by Tukey's test. ** $P<0.01$.

Discussion

Surface tension

These results imply that a greater spreading factor on the surface due to lower surface tension resulted in a greater spreading of the droplets and therefore enabled reduction of the spraying liquid (Matuo *et al*., 1989). The solution with glyphosate has a diminution the reduction in surface tension when vegetable oil and mixture tributyl citrate + polydimethylsiloxane was added, except at 180 seconds (Fig. 1).

Andrade *et al*. (2010) observed that the addition of oil, either mineral or vegetable, to an acaricide in the spraying liquid reduced the maximum quantity of liquid retained by the leaves of citrus plants, which suggested the possibility of reducing the amount of solution needed for good coverage of the plant. Maciel *et al*. (2010) reported that mineral oil proved effective in reducing the surface tension for tank mixing with glyphosate formulations and with chlorimuron-ethyl.

Contact angle on the leaves of Ipomoea hederifolia

It is known in the technical-scientific field that the contact angle may vary according to the surfaces. In natural targets, the highest levels of wetting with aqueous solutions were obtained through the lower surface tension and contact angles of the droplets, but this property is dependent on the surface characteristics of plant species (Iost & Raetano, 2010). Monquero *et al*. (2005) observed that the amount of wax per unit of leaf area was greater in *I. hederifolia* (38.5 µg cm^{-2}) compared with the other weeds studied. The same author reported that *I. hederifolia* has a rough leaf surface, glandular trichomes and paracytic stomata.

The effect of adjuvants on the physicochemical characteristics of aqueous solutions may depend on their chemical composition and formulation (Cunha & Alves, 2009). These authors observed that changes in dosage influenced the physicochemical characteristics of the adjuvants assessed in different ways. The pH, surface tension and viscosity were the proprieties most sensitive to the addition of adjuvants to the tested solutions.

These results imply that a greater spreading factor on the surface due to lower surface tension can result in a greater spreading of the droplets and therefore the possibility of reduction of the spraying liquid.

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