

Original Research Article

pH of Water and Tank Mixture Between Growth Regulator and Agrochemicals in Wheat

ABSTRACT

Aims: Water is used in spray tank mixtures of herbicides, fungicides, insecticides and growth regulators. The pH of water is a factor that can influence the efficiency of an application. The aim of this study was to evaluate, under field conditions, the effect of pH of the water used in the tank mixture spraying of trinexapac-ethyl, (imidacloprid + beta-cyfluthrin), (trifloxystrobin + tebuconazole) and iodosulfuron-methyl on plant height, agronomic traits and phytotoxicity caused to wheat plants.

Study design: The study used a randomized block design with four replications. The treatments were distributed into a 2 x 13 factorial arrangement.

Place and Duration of Study: A field experiment was carried out during the 2016 growing season, from July, 22 to December, 5. The experiment was conducted at experimental farm of Santa Catarina State University, Lages, Santa Catarina state, Brazil.

Methodology: The treatments consisted of the presence and absence of a pH reducer (phosphoric acid) and thirteen mixtures corresponding to different combinations of the trinexapac-ethyl growth regulator and iodosulfuron-methyl herbicide, (trifloxystrobin + tebuconazole) fungicide and the (imidacloprid + beta-cyfluthrin) insecticide.

Results: The use of low pH water did not increase phytotoxicity caused by the mixtures of trinexapac-ethyl, (imidacloprid + beta-cyfluthrin), (trifloxystrobin + tebuconazole) and iodosulfuron-methyl. There was no effect of the pH reducer and the mixtures on plant lodging, yield components and wheat grain yield.

Conclusion: The use of a spray solution at pH 4.0 enhances the effect of trinexapac-ethyl in decreasing plant height, but without changing the productive potential of wheat.

Keywords: *Triticum aestivum*, pesticides, acidity, spraying, tank mix

1. INTRODUCTION

The mixture of agrochemicals in a spray tank is a common practice among farmers [1]. However, this may involve herbicides, fungicides, insecticides, foliar fertilizers and growth regulators, especially in cereals. The physicochemical properties of these substances are altered in aqueous medium and may influence the effectiveness of the tank mixture [2]. Water was used as diluent in all spray mixtures.

The pH of water is a factor that can influence the efficiency of spray application. When the pH is high, alkaline hydrolysis of the products may occur, given that the dissociation constant of ionic molecules depends on the pH. At low pH the hydrolysis rate is slow, maintaining the leaf wet for longer [3].

Reducing the pH value of the spray solution is a promising technique in improving agrochemical absorption, reducing product doses and production costs and thereby maintaining efficient control. Inoue et al. [4] observed that a lower dose of glyphosate and the addition of a pH reducer to the spray solution enabled more efficient weed control compared to the same dose applied without the pH reducer. Applying gluphosinate with

31 water at a pH of 4.0 resulted in lower weed density and biomass compared to water with a
32 pH of 9.0 [5]. Applying the herbicide mesotrione with water at pH 6.5 exhibited the same
33 weed control percentage as the solution prepared with water at a pH of 4.0, but was higher
34 than the solution with a pH of 9.0 [6].

35
36 During agrochemical formulation, precautions are taken so that molecules can tolerate slight
37 variations in pH, but extreme fluctuations may affect their stability [7]. To correct the spray
38 solution, pH is generally lowered by adding a weak or diluted acid. Using pH reducers,
39 primarily acids such as phosphoric acid, is a common practice in agrochemical applications
40 aimed at raising the efficiency of the mixtures. In a mixture containing different classes of
41 agrochemicals, pH reducers can heighten the effect of these combinations, whether by
42 reducing incompatibility or chemically stabilizing the molecules, mainly for products that
43 require a pH between 3 and 5, thereby avoiding their hydrolysis [8].

44
45 The aim of this study was to assess, under field conditions, the effect of the pH of water
46 used in spray tank mixtures of plant growth regulator (trinexapac-ethyl), insecticide
47 (imidacloprid + beta-cyfluthrin), fungicide (trifloxystrobin + tebuconazole) and herbicide
48 (iodosulfurom-methyl) on plant height, agronomic characteristics and phytotoxicity caused to
49 wheat plants.

50

51 **2. MATERIAL AND METHODS**

52

53 **2.1 Site Location and Sowing Date**

54

55 The experiment was conducted in Lages, Santa Catarina state, Brazil from July 22 to
56 December 5, 2016 with the wheat cultivar BRS Gralha Azul. The cultivar is of medium plant
57 height, ranging from 80 to 100 cm, with an average number of tillers and moderate lodging
58 tolerance [9].

59

60 Direct seeding was employed, using a plot seeder (Sêmina, Embrapa-Semeato), with
61 soybean as the preceding crop. The plots were composed of 5 rows 5 m in length, spaced
62 0.2 m apart and 0.5 m between plots.

63

64 According to the results of soil analysis, basal dressing fertilizer was used with the
65 application of 30 kg ha⁻¹ of nitrogen, 80 kg ha⁻¹ of P₂O₅ and 60 kg ha⁻¹ of K₂O at seeding and
66 90 kg ha⁻¹ of N as top dressing at the start of tillering. This fertilizer aimed at a potential yield
67 of 4 t of grains per hectare, based on the Soil Chemistry and Fertility Commission - RS/SC
68 [10].

69

70 Weed, pest and disease control were carried out as needed, using the chemical products
71 recommended for the crop. Chemical products were not applied 15 days before and 28
72 days after the treatments, to prevent interference in the results, primarily the degree of
73 phytotoxicity.

74

75 **2.2 Treatments and Experimental Design**

76

77 The experimental design consisted of random blocks with four repetitions. Treatments were
78 distributed into a 2 X 13 factorial design, with the presence and absence of a pH reducer
79 and 13 mixtures corresponding to the different interactions between the plant growth
80 regulator (100 g i.a. ha⁻¹ of trinexapac-ethyl) and herbicide (5 g i.a. ha⁻¹ of iodosulfurom-
81 methyl), fungicide (75+150 g i.a. ha⁻¹ of trifloxystrobin + tebuconazole) and insecticide
82 (55+84 g i.a. ha⁻¹ of imidacloprid + beta-cyfluthrin), as described in Table 1.

83

84 **Table 1. Description of the different mixture combinations between the growth**
 85 **regulator, herbicide, insecticide and fungicide, Lages – SC**
 86

Treatment	Number	Description
Control*	1	control, only water
GR	2	trinexapac-ethyl
GR+I	3	trinexapac-ethyl + (imidacloprid + beta-cyfluthrin)
GR+F	4	trinexapac-ethyl + (trifloxystrobin + tebuconazole)
GR+H	5	trinexapac-ethyl + iodosulfurom-methyl
GR+F+I	6	trinexapac-ethyl + (trifloxystrobin + tebuconazole) + (imidacloprid + beta-cyfluthrin)
GR+H+I	7	trinexapac-ethyl + iodosulfurom-methyl + (imidacloprid + beta-cyfluthrin)
GR+H+F	8	trinexapac-ethyl + iodosulfurom-methyl + (trifloxystrobin + tebuconazole)
GR+F+I+H	9	trinexapac-ethyl + (trifloxystrobin + tebuconazole) + (imidacloprid + beta-cyfluthrin) + iodosulfurom-methyl
H+F	10	iodosulfurom-methyl + (trifloxystrobin + tebuconazole)
H+I	11	iodosulfurom-methyl + (imidacloprid + beta-cyfluthrin)
F+I	12	(trifloxystrobin + tebuconazole) + (imidacloprid + beta-cyfluthrin)
F+I+H	13	(trifloxystrobin + tebuconazole) + (imidacloprid + beta-cyfluthrin) + iodosulfurom-methyl

87 *T, treatments; RC, growth regulator; I, insecticide; F, fungicide and H, herbicide
 88

89 In the presence of the pH reducer, the pH of the water used to prepare the treatments was
 90 changed to 4.0, using 1 mol/L phosphoric acid. In the absence of the reducer, the pH of the
 91 water was not altered, maintaining the natural pH of 6.5. The water used in the experiment
 92 originated in the reverse osmosis purification process, in order to avoid other contaminants
 93 (chemicals) that could potentially interfere in the assessment. After preparation, the spray
 94 solutions were applied using a CO₂-pressurized backpack sprayer, with XR11002-VP Teejet
 95 spray nozzles, regulated to a flow rate of 200 L ha⁻¹. Treatments were applied on
 96 September 16 (58 DAS) when the plants were at the onset of stem elongation – first node
 97 visible, considering growth stage 31 (GS31) of Zadoks scale [11].
 98

99 2.3 Evaluated Parameters

100
 101 Wheat Plant Phytotoxicity: was assessed at 1, 7, 14, 21 and 28 days after application (DAA)
 102 of the mixtures based on scale scores, where 1 represents no symptoms and 9 plant death
 103 (Table 2), in line with the methodology proposed by the European Weed Research Council
 104 – EWRC [12].
 105

106 **Table 2. EWRC scores to assess the intensity of phytotoxicity caused by the**
 107 **mixture of growth regulator, herbicide, insecticide and fungicide in the wheat crop,**
 108 **Lages – SC**

Score	Description
1	No symptoms.
2	Visible discoloration in some plants.
3	Visible discoloration in numerous plants.
4	Strong discoloration with no necrosis.

5	Necrosis in some leaves, especially at the edges.
6	More than 50% of the leaves exhibiting necrosis.
7	More than 70% of buds and leaves destroyed.
8	Severe damage, with small green areas on the plants.
9	Plant death

109

110 Plant Height (PH). The mean plant height was assessed at pre-harvest, measured from the
111 crown to the apex of the spike (less the awn) using a graduated ruler (mm). This
112 assessment was conducted in 20 plants randomly collected from each plot. Plants in the
113 central row of each experimental plot were also sampled to assess their morpho-agronomic
114 characteristics.

115

116 Number of Grains per Spike (NGS): the 10 ears were collected from the central row of each
117 plot, in which the NGS was handled quantified.

118

119 Number of Spikelets per Spike (NSS): the 10 ears were collected from the central row of
120 each plot, in which the NSS was handled quantified.

121

122 Lodging Index (LI): the Belgian lodging index of the plants was assessed, using the
123 equation $LI = S \times I \times 2$, where S = lodged surface between 1 and 10, where 1 is no lodging
124 and 10 totally lodged and I = lodging intensity, ranging from 1 to 5, where 1= vertical plants,
125 5 = horizontal plants and 2 = correction coefficient [13, 14].

126

127 Grain ripeness was identified on December 1, 2016 (Zadoks code GS92) and the crop was
128 harvested in the useful area of each experimental unit, using a self-propelled plot harvester.
129 After harvest, the following were determined in a sample of each plot:

130

131 Hectoliter weight (HW): The weight of hectoliter was measured according to the Brazilian
132 official wheat grain quality roles (Brazil, Ministry of Agriculture, Livestock and supply,
133 Normative role 38, from November 30 of 2010), using a hectoliter weight analyzer (Dalle-
134 Molle, model T40EL, 0.25L of capacity). Briefly, grain samples from each experimental plot
135 were placed in the analyzer for volume determination and then weighed using a Dalle-Molle
136 balance.

137

138 The percentage of grains larger than 1.75 mm ($S_{>1.75}$): The $S_{>1.75}$ was evaluated in a
139 100g sample from each experimental plot using a 1.75 x 20 mm mesh sieve.

140

141 The 1000 grain weight (1000GW): A sample of a thousand grains', obtained from each
142 experimental plot were electronically counted (Sanick, model ESC 2011) and weighted
143 using a precision balance and expressed in grams (g).

144

145 Grain yield (GY) was calculated based on the weight of grains obtained in the useful study
146 area of the plots, corrected for 13% moisture and converting the value for one hectare.

147

148 The PH, NGS, NSS, LI, HW, 1000GW and GY were evaluated in a similar manner as a
149 described for oat according to Uarrotta et al. [14].

150

151 2.4 Statistical Analysis

152

153 The data obtained were submitted to analysis of variance using the F-test ($p \leq 0.05$). When
154 statistical significance was reached, the means of the mixtures were compared by applying
155 the Scott-Knott test at 5% probability and the means of the pH reducer by Tukey's test at 5

156 % probability. The evolution of phytotoxicity over time was determined by regression
157 analysis. Hierarchical cluster was carried out using Ward's method, applying Euclidean
158 distance as dissimilarity measure. Treatments were grouped according to plant
159 phytotoxicity. Statistical analysis was performed using R software [15].
160

161 3. RESULTS AND DISCUSSION

162
163 Analysis of variance showed effect of pH reducer, mixtures and interaction of pH reducer
164 with mixtures ($p < 0.05$) on PH (Table 3). For NSS, there was an effect only for the pH
165 reducer, and for HW only a single effect of mixtures (Table 3).
166

167 **Table 3. Analysis of variance, mean square, residual, mean and coefficient of**
168 **variation with respect to the application of tank mixtures among plant growth**
169 **regulator, herbicide, insecticide and fungicide with and without the pH reducer on**
170 **wheat plant traits. Lages – SC, 2016 growing season**

Source of variation	Mean Square						
	PH (cm)	GY (kg.ha ⁻¹)	HW (kg.100L ⁻¹)	1000GW (g)	NSS (n°)	NGS (n°)	S>1.75 (%)
pH reducer (A)	129.4*	50349 ^{ns}	1.0 ^{ns}	1.0 ^{ns}	10.7*	0.2 ^{ns}	0.48 ^{ns}
Mixtures (B)	235.9*	623789 ^{ns}	2.4*	7.0 ^{ns}	3.1 ^{ns}	27.7 ^{ns}	0.13 ^{ns}
AxB	64.1*	335005 ^{ns}	0.5 ^{ns}	9.4 ^{ns}	3.4 ^{ns}	10.6 ^{ns}	0.19 ^{ns}
Block	48.0 ^{ns}	294715 ^{ns}	2.9 ^{ns}	0.6 ^{ns}	2.8 ^{ns}	6.3 ^{ns}	0.06 ^{ns}
Residual	19.8	823768	0.9	5.5	1.9	23.0	0.3
Mean	81.1	3880.6	77.3	37.3	16.9	30.5	99.0
CV (%)	5.5	23.4	1.2	6.3	8.2	15.7	0.5

171 ^{ns}, not significant ($p > 0.05$) and ** significant ($p \leq 0.05$)
172

173 Applying trinexapac-ethyl alone or in a mixture with other agrochemicals, in the presence or
174 not of the pH reducer, decreased plant height, in contrast to treatments without the growth
175 regulator (Table 4). Without the pH reducer, the mixtures that contained trinexapac-ethyl
176 resulted in smaller plants, differing from the control and plants treated with mixtures without
177 the growth regulator. A similar result occurred when the mixtures were applied with a pH
178 reducer. However, GR+H+F and GR+H+I+F treatments produced shorter plants, and GR,
179 GR+I, GR+F, GR+H, GR+F+I and GR+H+I mixtures exhibited intermediate values, but with
180 lower plant height than that obtained without the plant growth regulator (Table 4).
181

182 When the pH of the spray solution declined to 4.0, GR, GR+I, GR+F and GR+H+I
183 treatments resulted in shorter plants, compared to those applied without reducing solution
184 pH. Trinexapac-ethyl is an acidic product with a pKa value of 4.6 [16]. Weak acidic products
185 and lowering the pH improves efficiency, given that less ionized molecules penetrate the
186 cuticle and the plasma membrane more easily [17]. According to Green & Cahill [18], the
187 syrup pH interferes in molecular activity. Reducing the pH facilitates cuticular penetration
188 and solubility, thereby improving molecular absorption and allowing for lower doses of the
189 products [4]. When assessing the effect of trinexapac-ethyl on the height of wheat plants,
190 Zagonel & Fernandes [19] and Stefen et al. [20] investigated the response to trinexapac-ethyl
191 by decreasing height as a function of applying this regulator. This may explain why GR,
192 GR+I, GR+F and GR+H+I treatments resulted in shorter plants when applied with pH 4.0
193 water, likely due to the greater absorption of the product. However, GR+H, GR+F+I,
194 GR+H+F and GR+F+I+H did not differ when applied with and without the pH reducer. This
195 may have occurred because of the interaction with other products.
196

197 The effect of reducing plant height on decreasing lodging was not observed, since the
198 climatic conditions did not favor lodging. Particularly, the mean PH values of 82.2cm (WoR)

199 and 80.0cm (WR) was below of observed for this cultivar, BRS Gralha Azul, that is 83 cm at
200 previous research [9].
201

202 **Table 4. Height of wheat plants as a function of tank mixture of trinexapac-ethyl (GR)**
203 **and iodosulfurom-methyl (H), trifloxystrobin + tebuconazole (F) and imidacloprid +**
204 **beta-cyfluthrin (I) with and without the pH reducer, Lages – SC. 2016 growing season**
205

Treatments	Plant Height (cm)	
	Without pH reducer (WoR)	With pH reducer (WR)
Control	85.5 aA	85.3 bA
GR	81.5 bA	73.5 dB
GR+I	81.0 bA	71.0 dB
GR+F	81.8 bA	73.0 dB
GR+H	78.3 bA	74.0 dA
GR+F+I	79.3 bA	75.0 dA
GR+H+I	80.3 bA	71.8 dB
GR+H+F	78.0 bA	78.0 cA
GR+F+I+H	76.3 bA	80.8 cA
H+F	84.3 aB	91.3 aA
H+I	87.5 aA	89.3 aA
F+I	87.5 aA	92.0 aA
F+I+H	87.8 aA	85.0 bA
Mean	82.2	80.0

206 *Means followed by the same lowercase letters in the column and uppercase on the row did*
207 *not differ according to the Scott-Knott test at 5% probability.*
208

209 Mixtures of trinexapac-ethyl, iodosulfurom-methyl, (trifloxystrobin + tebuconazole) and
210 (imidacloprid + beta-cyfluthrin) produced a significant effect on HW, with the best results
211 obtained in treatments GR+I, GR+F, GR+H, GR+F+I, GR+H+I, GR+H+F, H+I and F+I
212 (Table 5). The HW indirectly expresses grain quality, and is more associated with the
213 genetic characteristics of the genotype and strongly related to gluten strength and industrial
214 flour quality [21]. Crop problems due biotic and abiotic factors that affect grain filling in
215 wheat may decrease HW values [22].
216

217 **Table 5. Hectoliter weight (HW) as a function of tank mixture of trinexapac-ethyl (GR)**
218 **and iodosulfurom-methyl (H), trifloxystrobin + tebuconazole (F) and imidacloprido +**
219 **beta-cyfluthrin (I) in the wheat crop, Lages – SC. 2016 growing season**
220

Treatments	HW (kg.100L ⁻¹)
Control	76.3 b
GR	76.8 b
GR+I	77.4 a
GR+F	77.9 a
GR+H	78.2 a
GR+F+I	77.9 a
GR+H+I	77.5 a
GR+H+F	77.3 a
GR+F+I+H	76.8 b
H+F	77.0 b
H+I	77.5 a

F+I	77.6 a
F+I+H	76.8 b
Mean	77.3

Means followed by the same letters do not differ according to the Scott-Knott test at 5% probability.

The number of spikelets per spike (NSS) was affected by the pH reducer (Table 6). WoR to prepare the spray solution, the mean NSS (17.3) was higher than the NSS, exhibiting WR (16.6). Despite this difference in NSS, there was no change in NGS or 1000GW.

Table 6. Number of spikelets per spike (NSS), as a function of the tank mixture of trinexapac-ethyl (GR) and iodosulfurom-methyl (H), trifloxystrobin + tebuconazole (F) and imidacloprid + beta-cyfluthrin (I) with and without the pH reducer in the wheat crop, Lages – SC. 2016 growing season

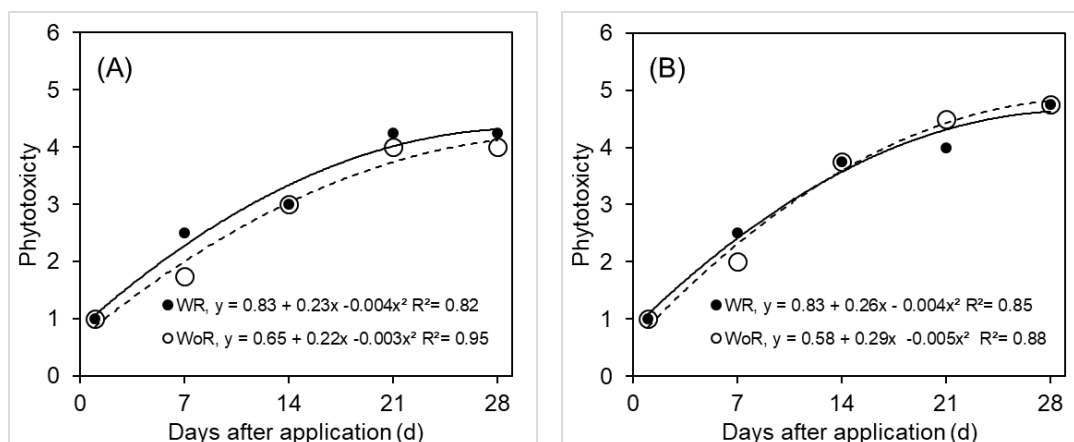
Treatments	Number of spikelets per spike (NSS)
Without pH reducer (WoR)	17.3 a
With pH reducer (WR)	16.6 b

Means followed by the different lowercase letters do differ according to Tukey's test at 5% probability.

According to Gondim et al. [23], the number of grains per spike and 1000 grains weight had a positive effect on grain yield. Since the application of mixtures WR or WoR had no effect, no significant change in grain yield was observed.

No phytotoxicity symptoms were detected at 1, 7, 14, 21 and 28 DAA in the treatments, control and treatment containing only trinexapac-ethyl (GR), with a score of 1 on the EWRC scale. The other treatments resulted in phytotoxicity scores ranged from 2 to 5; with the first phytotoxicity symptoms observed after 7 DAA. At 7, 14, 21 and 28 DAA there was a linear increase in phytotoxicity in GR+H+I, F+I, and F+I+H (Fig. 2A, 3B and 3C) and a quadratic response was detected in GR+I, GR+F, GR+F+I, GR+H+F, GR+F+I+H and H+F (Fig. 1A, 1B, 1D, 2B, 2C and 2D).

The GR+I (WoR) and H+I (WR) treatments (Fig 1C and 3A) showed a linear response when the pH of the water was reduced to 4.0, and without the pH reducer the response was quadratic. Both treatments were attributed only a max score of 5 on the scale.



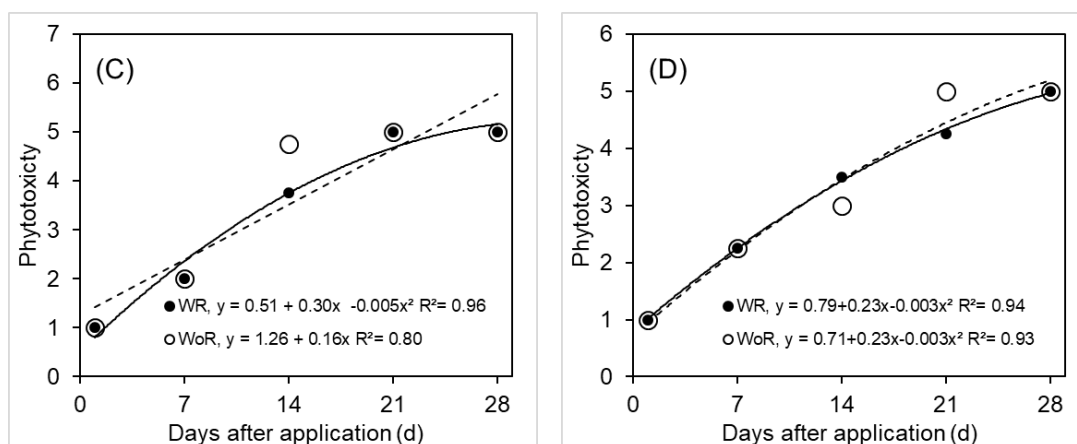


Fig. 1. Phytotoxicity in wheat plants caused by foliar application of tank mixtures with (WR) and without the pH reducer (WoR). 2016 harvest. (A) trinexapac-ethyl + (imidacloprid + beta-cyfluthrin), (B) trinexapac-ethyl + (trifloxystrobin + tebuconazole), (C) trinexapac-ethyl + iodosulfurom methyl, (D) trinexapac-ethyl + (trifloxystrobin+tebuconazole) + (imidacloprid + beta-cyfluthrin)

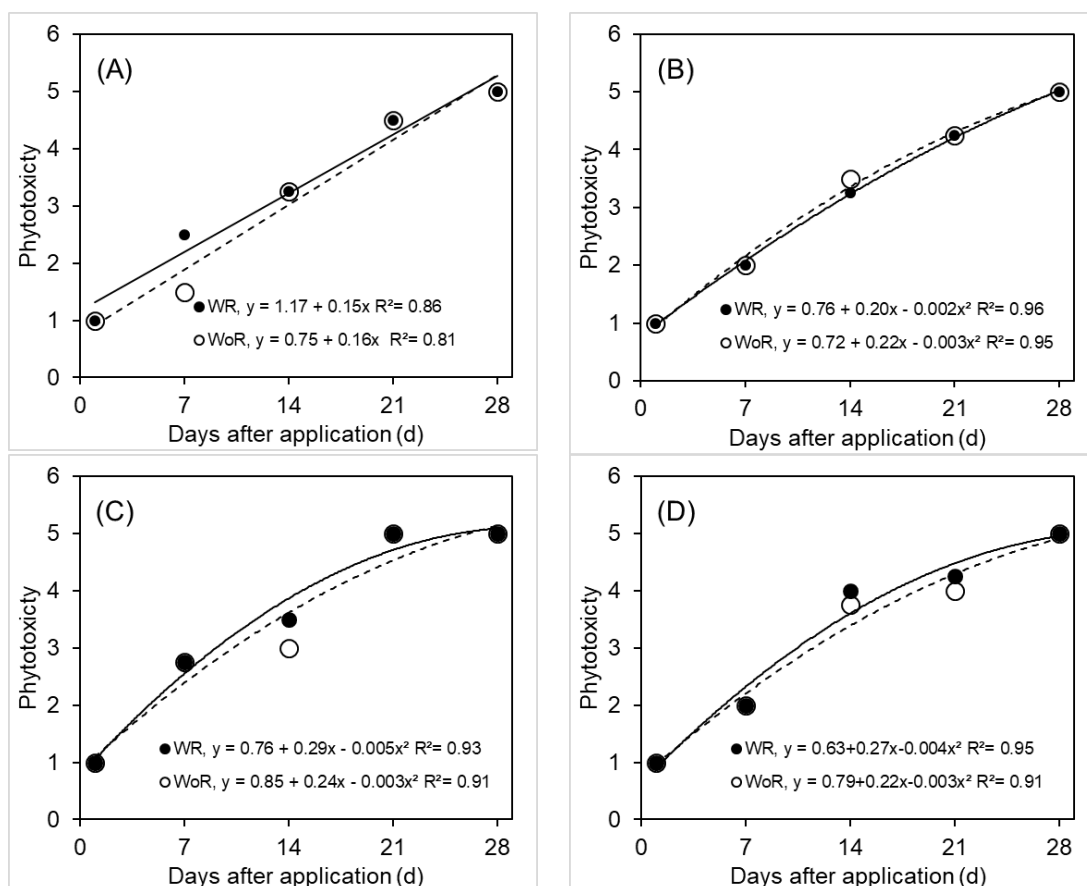
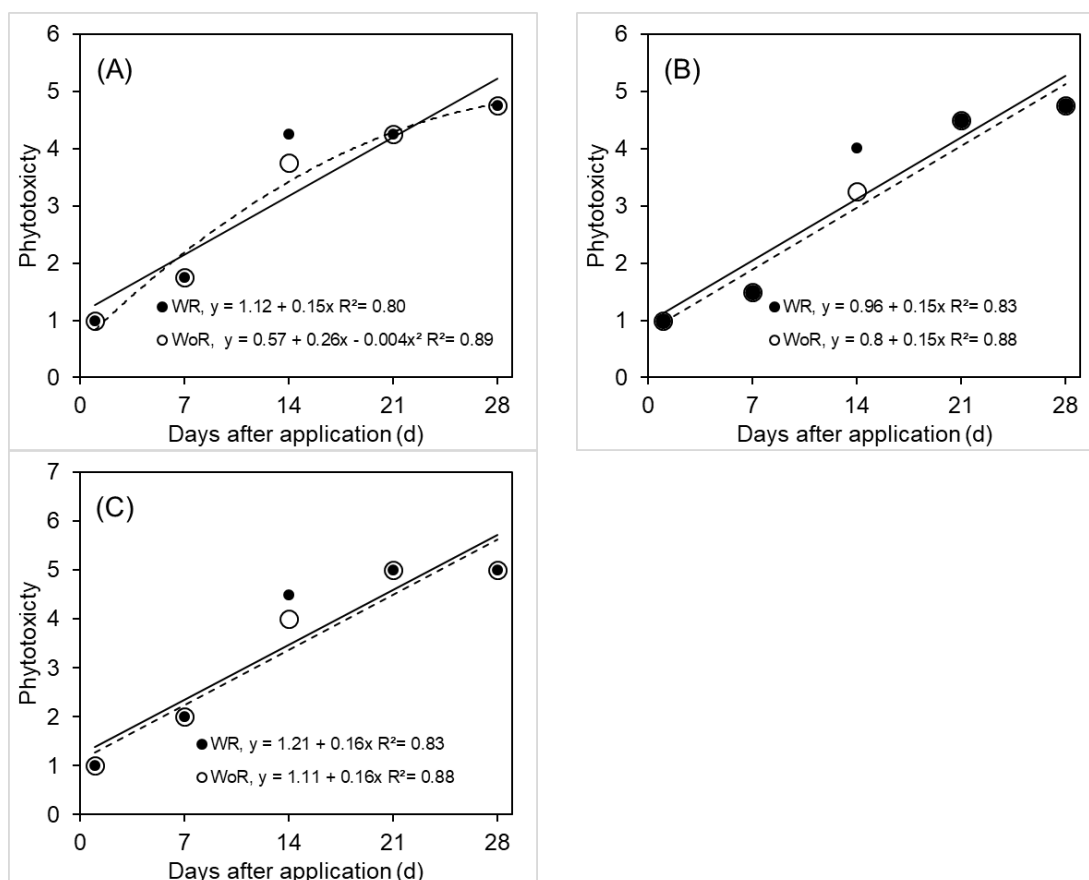


Fig. 2. Phytotoxicity in wheat plants caused by the foliar application of tank mixtures with and without the pH reducer. 2016 growing season. (A) trinexapac-ethyl,

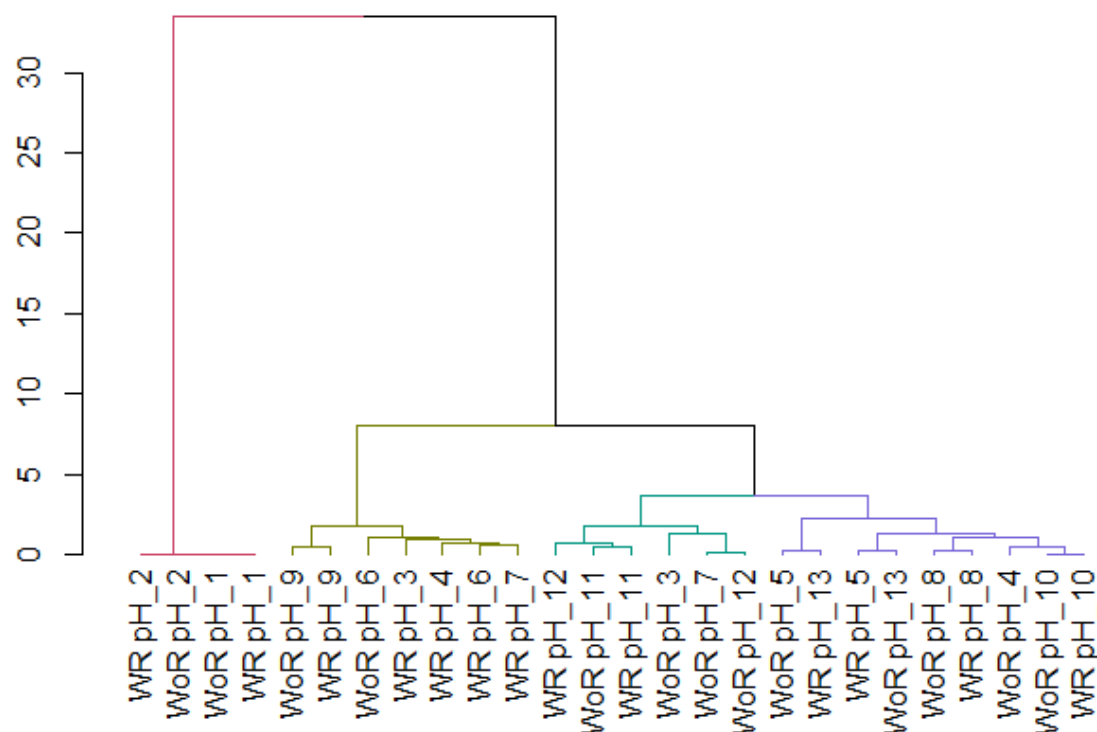
262 iodosulfurom methyl + (imidacloprid + beta-cyfluthrin), (B) trinexapac-ethyl,
 263 iodosulfurom methyl + (trifloxystrobin+tebuconazole), (C) trinexapac-ethyl +
 264 (trifloxystrobin + tebuconazole) + (imidacloprid + betacyfluthrin) + iodosulfurom
 265 methyl and (D) iodosulfurom methyl + (trifloxystrobin+tebuconazole)
 266



267
 268 **Fig. 3. Phytotoxicity in wheat plants caused by the foliar application of tank mixtures**
 269 **with and without the pH reducer: (A) iodosulfurom methyl + (imidacloprid + beta-**
 270 **cyfluthrin), (B) (trifloxystrobin + tebuconazole) + (imidacloprid + beta-cyfluthrin) and**
 271 **(C) (trifloxystrobin + tebuconazole) + (imidacloprid + beta-cyfluthrin) + iodosulfurom**
 272 **methyl**
 273

274 Reducing the pH of water to 4.0 in the mixtures had no effect on phytotoxicity. The
 275 maximum score obtained for phytotoxicity was 5 on the EWRC scale, for treatments "WoR"
 276 and "WR" a reduction of pH to 4.0. Decreasing the pH of the spray solution interferes in the
 277 ease of cuticular penetration, improving agrochemical absorption [17]. The hydrolysis rate is
 278 slower at a lower pH, which keeps the leaf wet for longer due to the neutral pH of its surface
 279 and with the spray solution pH. It was expected that lower water pH would lead to higher
 280 plant phytotoxicity, owing to greater product absorption; however, this was not observed in
 281 our experiment. According to Whitford et al. [24], herbicides, fungicides and insecticides
 282 function better when the water used has a pH between 4.0 and 6.5. Since the pH range
 283 used in the experiment was between 4.0 and 6.5, there was no difference in phytotoxicity
 284 between the plants treated with mixtures of trinexapac-ethyl, (trifloxystrobin +
 285 tebuconazole), iodosulfurom-methyl and (imidacloprid + beta-cyfluthrin) at pH 4.0 or 6.5.
 286

287 Hierarchical clustering was applied to the phytotoxicity data, in order to group treatments
 288 according to their impact on wheat plants. Cluster analysis separated the 26 treatments (2 x
 289 13; with and without a spray solution pH reducer combined with the 13 mixtures of products)
 290 into 4 groups (Fig. 4).
 291



292
 293
 294 **Fig. 4. Hierarchical dendrogram of the thirteen mixtures with and without a spray**
 295 **solution pH reducer showing the similarities and dissimilarities between treatments**
 296 **in terms of the degree of phytotoxicity caused to plants. WoR pH: without a pH**
 297 **reducer; WR pH: with a pH reducer combined to products: (GR) trinexapac-ethyl, (I)**
 298 **imidacloprid + beta-cyfluthrin, (F) trifloxystrobin + tebuconazole and (H)**
 299 **iodosulfurom-methyl; Treatments: 1 Control, 2 GR, 3GR+I, 4GR+F, 5 GR+H, 6 GR+F+I,**
 300 **7 GR+H+I, 8 GR+H+F, 9 GR+F+I+H, 10 H+F, 11 H+I, 12 F+I and 13 F+I+H**
 301

302 The first group consisted of the control and trinexapac-ethyl with and without the pH
 303 reducer. These treatments did not cause phytotoxicity in wheat plants. The second group
 304 was composed of trinexapac-ethyl + (trifloxystrobin + tebuconazole) + (imidacloprid + beta-
 305 cyfluthrin) + iodosulfurom-methyl and trinexapac-ethyl + (trifloxystrobin + tebuconazole) +
 306 (imidacloprid + beta-cyfluthrin) applied with and without the pH reducer and trinexapac-ethyl
 307 + imidacloprid + beta-cyfluthrin, trinexapac-ethyl + (trifloxystrobin + tebuconazole),
 308 trinexapac-ethyl + iodosulfurom-methyl + (imidacloprid + beta-cyfluthrin) with the syrup pH
 309 reducer. The third group contained (trifloxystrobin + tebuconazole) + (imidacloprid + beta-
 310 cyfluthrin), iodosulfurom-methyl + (imidacloprid + beta-cyfluthrin) with and without the pH

reducer, trinexapac-ethyl + (imidacloprid + beta-cyfluthrin) and trinexapac-ethyl + iodosulfurom-methyl + (imidacloprid + beta-cyfluthrin) without the pH reducer. The fourth group consisted of (trifloxystrobin + tebuconazole) + (imidacloprid + beta-cyfluthrin) + iodosulfurom-methyl, trinexapac-ethyl + iodosulfurom-methyl, trinexapac-ethyl + iodosulfurom-methyl + (trifloxystrobin + tebuconazole), iodosulfurom-methyl + (trifloxystrobin + tebuconazole) with and without the pH reducer and trinexapac-ethyl + (trifloxystrobin + tebuconazole) without the pH reducer.

The clustering of mixtures with and without the pH reducer indicates similar traits in terms of the degree of phytotoxicity caused to wheat plants. The cophenetic correlation obtained was 98%.

Most of the independent treatments applied “WR” or “WoR” were placed in the same group. However, the application of trinexapac-ethyl + (imidacloprid + beta-cyfluthrin), trinexapac-ethyl + (trifloxystrobin + tebuconazole) and trinexapac-ethyl + iodosulfurom-methyl + (imidacloprid + beta-cyfluthrin) with a spray solution pH reducer caused similar phytotoxicity to that provoked by trinexapac-ethyl + (trifloxystrobin + tebuconazole) + (imidacloprid + beta-cyfluthrin) + iodosulfurom-methyl and trinexapac-ethyl + (trifloxystrobin + tebuconazole) + (imidacloprid + beta-cyfluthrin), that is, wheat plant phytotoxicity was similar to that caused by treatments with a larger number of products in the mixture. Thus, the number of agrochemicals mixed in the spray tank is not a determining factor in strengthening the phytotoxic effect on wheat plants. In general, these results are similar to those obtained by Gazziero [1].

4. CONCLUSION

The use of mixtures and water with a pH of 4 had no effect on wheat yield. The mixtures of trinexapac-ethyl, iodosulfurom-methyl, (imidacloprid + beta-cyfluthrin) and (trifloxystrobin + tebuconazole) led to moderate phytotoxicity in wheat plants. However, lowering the pH of water used in the spray solution did not influence the degree of phytotoxicity. Using spray solution with a pH of 4.0 increases the effect of trinexapac-ethyl on reducing plant height.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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