SHORT COMMUNICATION

Impact of Sublethal Doses of 2,4-D, Simulating Drift, on Tomato Yield

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Tomato is considered one of the most sensitive crops regarding 2,4-D drift. In many cases, such susceptibility has led to important restrictions in the use of 2,4-D based products. Field experiments were carried out for two consecutive years in tomato, by applying sublethal doses of 2,4-D (ranging from 0.42 to 13.44 g a.i. ha$^{-1}$) directly to plants, at different stages of growth, as a simulation of eventual drifts to the crop. The range of rates was based on the assumption of a 0.0625–2.0% drift level of a 1 L ha$^{-1}$ of the most common formulated herbicides. For this crop, the range of rates between 0.42 and 13.44 g a.i. ha$^{-1}$ applied at the beginning of flowering caused a linear crop reduction. On the other hand, rates ≤13.44 g a.i. ha$^{-1}$ applied after full development of fourth truss stage or latter had no effect on crop yield or development. For tomato, tolerance to 2,4-D strongly increases with plant age.

Key Words: Symptoms; Phenoxy herbicides; Injury.

INTRODUCTION

The growing interest of farmers for sustainable land management techniques in Brazil has led to an area of over 16 million hectares of no-tillage a year. The demand for herbicides, both for weed control in crops and for burndown, has followed such growth, and herbicides like glyphosate and 2,4-D are among the most used. For 2,4-D, more than 50% of the volume applied is related to burndown of no-till areas before summer growing season.$^{[1]}$

Brazil is the world's fifth largest producer of tomatoes, with an estimated annual production of $3.3 \times 10^6$ tons of fruits.$^{[2]}$ The crop is the second in

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economic importance among horticultural crops and since it is mainly cultivated by small growers, the tomato agribusiness has also an important social function, due to its effect on employment of labor hands in fields.

Off-target drift of phenoxy herbicides, such as 2,4-D, has led to many restrictions on the use in some states in Brazil, as a result of the problems caused by herbicide absorption by sensitive crops, leading to visual injuries and economic losses. The effects of lethal rates of 2,4-D for dicotyledonous species are well known, but the effects resulting from exposure to sublethal rates are less documented. A wide range of plant responses can be expected after exposition to phenoxy herbicides, but the level of injury usually depends on the drift intensity (or applied rate) and on the stage of plant development. Because drift is usually an unexpected event, not much information is available dealing with losses caused by 2,4-D in sensitive crops. This work was aimed to evaluate the correlation between simulated levels of 2,4-D drift and economic losses in tomato, as well as to develop knowledge on 2,4-D damages vs. crop stage of growth.

MATERIALS AND METHODS

Field experiments were carried out during two consecutive years in Maringá, PR (Brazil). The first one was conducted during 2002–2003 and the second during 2003/2004 growing season. In both years the same tomato hybrid (Débora Plus) was grown staked in paired lines, under drip irrigation, following all recommended management instructions for this cultivar. Seeds were sown in trays and transplants were taken to field after 30 days, at the stage of four to six true leaves. Sixteen seedbeds were prepared, 0.5 m apart of each other, being each one 42 m long, 1 m wide, and 0.20 m high. Transplants were planted with a within-row spacing of 0.30 m and between-row spacing of 1.50 m. Nylon twine was strung horizontally along the line of stakes, wrapping the stakes tightly and encircling the plants. Plants were pruned to a single stem, and tying and removing side shoots from the main stem were repeated every seven to ten days. All plants were pruned to seven trusses, as is done by the major regional tomato growers.

In the first year, 2,4-D was applied directly to aerial part of the plants at rates of 0.42, 0.84, 1.68, 3.36, 6.72, and 13.44 g a.i. ha\(^{-1}\). At this point, most plants had just started the anthesis of first truss. For each applied rate, a no-spray check was left side by side the applied plot, with the intent of providing a site-specific correction when data were submitted to covariance analysis. Such a “two fold checks” arrangement was previously detailed by Constantin et al.\(^{[5]}\) and Fagliari et al.\(^{[6]}\) Under field conditions, such rates would be equivalent to drifts of 0.0625, 0.125, 0.25, 0.5, 1.0, and 2.0% of the recommended desiccation dosage of the most common 2,4-D formulated herbicides (670 g a.i. ha\(^{-1}\)).
The herbicide was applied 35 days after transplantation, immediately before anthesis of the first truss.

In the second year, two rates of 2,4-D were applied (equivalent to 1.0 and 2.0% simulated drifts) in three different stages of crop development (4th, 5th, and 6th truss full development). In both applications, a CO2-based backpack sprayer under constant pressure (30 lb pol−2) was utilized. The sprayer was equipped with 110.02 flat fan nozzles, propitiating a volume of application of 200 L ha−1. To assure no contamination of neighbor plots, a lot of care was taken during field applications. During spraying, all the perimeter of field plots was covered with a small plastic, 2 m high greenhouse, and this coverage was not removed from plots for at least five minutes after application.

For the first year, a randomized blocks design with four replicates was used. Each experimental unit was constituted by 40 plants. For the second year, a factorial scheme (2 x 3) + 1 (two simulated drift levels, three stages of crop development, and an additional no-spray check) was used, with the same experimental design and number of replicates. For both experiments, a covariance procedure was set to data to provide a local control within each block. Data from experiments were submitted to ANOVA and, for the first year, to regression analysis.

RESULTS AND DISCUSSION

Although a lot is known about the mechanism of action of phenoxy herbicides in plants, little has been done to estimate what are the real damages imposed to sensitive crops as a result of drift. For tomato, simulating different levels of 2,4-D drift resulted in a linear decrease in number of fruits per plant (Fig. 1), and, as a result, a major negative effect in crop yield (Fig. 2). A simulated drift of 2.0% (13.44 g a.i. ha−1) resulted in an estimated 92% reduction of in number of fruits per plant and 93% in total crop yield. Using the regression equations of Figures 1 and 2, an estimated loss of two fruits per plant or 3.92 t ha−1 should be considered for each gram of acid equivalent of 2,4-D reaching plant foliage.

The significant losses caused by 2,4-D sublethal doses may be related both to the systemic nature of phenoxy herbicides and to source-sink balance. Usually, bud or small fruits development demand a great amount of assimilates, what may have helped in carrying more significant amounts of 2,4-D to these drains. Also, hormonal-type herbicides are rapidly transported to meristematic areas.[7] Since hormonal herbicides are characterized by providing evident symptoms even under very low concentrations in plants, the final result is the drop or abortion of flowers and fruits.

The average weight of fruits was not affected by any rates within the range used in the first experiment (data not shown). The severe damage in crop yield
was caused mainly by drop or abortion of flowers and flowering buds, what is evident by the effect of treatments on number of fruits per plant. Other visual symptoms included moderate leaf curling and stem epinasty. Data presented in this work are similar to the results obtained by Robbins and Taylor\(^8\) and Joseph and Peter\(^9\). On the other hand, Hemphill and Montgomery\(^10\) and Singh and

**Figure 1:** Number of fruits per plant as a function of 2,4-D rates applied to tomato at the beginning of flowering stage.

**Figure 2:** Crop yield as a function of 2,4-D rates applied to tomato at the beginning of flowering stage.
Table 1: Effect of simulated drifts of 2,4-D on tomato yield at three different stages of tomato development.

<table>
<thead>
<tr>
<th>Simulated drift of 2,4-D (g a.i. ha(^{-1}))</th>
<th>6.72</th>
<th>13.44</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage of crop development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 trusses</td>
<td>59.37</td>
<td>59.24</td>
</tr>
<tr>
<td>5 trusses</td>
<td>61.38</td>
<td>60.47</td>
</tr>
<tr>
<td>6 trusses</td>
<td>63.28</td>
<td>62.72</td>
</tr>
</tbody>
</table>

Combined stage x drift level average yield: 61.08 t ha\(^{-1}\).
Average yield no-spray check: 61.10 t ha\(^{-1}\).
CV=11.9%.
LSD lines—10.97 t ha\(^{-1}\); LSD columns—13.38 t ha\(^{-1}\).

Singh\(^{[11]}\) found an improved flowering and number of fruits by using equivalent rates of 2,4-D in tomato.

In the second experiment, rates of 1.0% (6.72 g a.i. ha\(^{-1}\)) and 2.0% (13.44 g a.i. ha\(^{-1}\)) were applied to tomato latter in plant cycle (when fourth, fifth, or sixth truss were fully grown, but before ripening). Results both from preliminary tests and from other crops\(^{[7]}\) provided evidence of increased tolerance by the tomato with plant aging. In the second experiment, no significant effects were observed, either for single factors or for their interaction. Also, the interaction between both factors was not significant (Table 1). According to Park,\(^{[12]}\) the greater tolerance of mature plants in relation to younger ones may be attributed to less penetration of 2,4-D through leaves, due to the increased cuticle thickness, less intense metabolism, and mainly due to the predominance of differentiated tissues in detriment of meristematic tissues, which are considered as the center of all biologic activity and site of action of 2,4-D.

CONCLUSION

Simulation of 2,4-D drift at the beginning of flowering stage was harmful to tomato within the range of simulated drift levels in this work, leading to severe decreases in number of fruits per plant and total crop yield. Simulated drifts of \(\leq 13.44\) g a.e. ha\(^{-1}\) did not provide any negative effect on tomato production when applied at full development of fourth truss or thereafter.

REFERENCES


