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Defining the Developmental Toxicity of the Herbicide Dicamba Using the Zebrafish Model System

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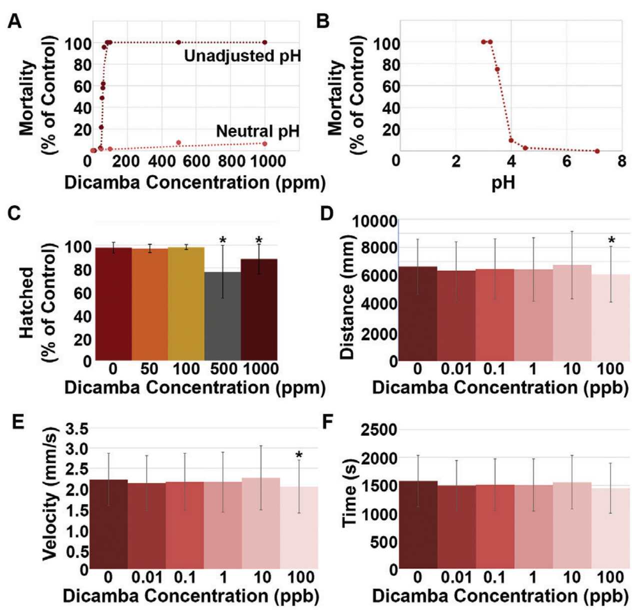
Use of the herbicide dicamba has been modest throughout the U.S.; however, with Monsanto's introduction of Xtend crops in 2016, dicamba use is expected to significantly increase. This rise poses a risk of dicamba entering drinking water supplies, especially in the midwestern United States. Currently, the U.S. Environmental Protection Agency (EPA) has not established a maximum contaminant level for dicamba in drinking water.

Because the toxicity of dicamba is not well understood or researched at this time, the aim of this study is to use the zebrafish model system to provide more insight into dicamba's developmental toxicity. To do this, zebrafish embryos were collected and exposed to different concentrations of dicamba throughout 120 hours post fertilization (hpf). Lethality and hatching rate were monitored every 24 hours, and a visual motor response test was used to assess behavioral changes at 120 hpf. Dicamba's acidity influenced the pH of the exposure media resulting in an LC_{50} of 56 ppm (mg/L). This concentration and those higher measured at a pH < 4. At pH < 4 mortality begins to occur in the developing zebrafish, and it is concluded lethality is based on acidic pH of exposure media and not dicamba. When exposure media was adjusted to neutral conditions, no lethality was observed at concentrations up to 1000 ppm. In the neutralized conditions, hatching rate decreased ($p < 0.05$). In the behavior test, zebrafish larvae were observed to be hypoactive at higher dicamba concentrations ($p < 0.05$). Overall, the findings of this study provide information on dicamba developmental toxicity for future studies focused on chemical mixtures.

Research advisor Jennifer Freeman writes: "Lucas is leading research in my group defining the developmental toxicity of the herbicide dicamba. His research is significant since new agrichemical products that are expected to have high use were recently introduced, increasing the risk of dicamba contamination in drinking water sources and potential for human exposure."



Developmental toxicity of dicamba. (A) The LC50 for dicamba with unadjusted pH (dark red) is 56 ppm at 120 hours post fertilization (hpf), while the LC50 for dicamba with adjusted neutralized pH (orange) has no difference from the control (N = 4, with 50 subsamples per treatment per replicate). (B) The LC50 curve for pH indicates an LC50 of 4.457 at 120 hpf (N = 4, with 50 subsamples per treatment per replicate). (C) A significant decrease in hatching rate was observed at 72 hpf for 500 and 1000 ppm dicamba treatment group (*p < 0.05; N = 4, with 50 subsamples per treatment per replicate; error bars represent standard deviation). For the neurobehavioral endpoints, (D) a significant decrease in total distance moved and (E) velocity was observed in the 100 ppb (µg/L) treatment group compared to the control, while no significant difference in (F) time spent moving was observed (*p < 0.05; N = 8, with 13 subsamples per treatment per replicate; error bars represent standard deviation).

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