**APPENDIX 2-6. Glyphosate Species Sensitivity Distribution (SSD) Analysis for Terrestrial Plants**

An SSD was fitted to vegetative vigor toxicity data of terrestrial plants exposed to glyphosate formulations. Seedling emergence was not fitted with an SSD due to low toxicity and lack of definitive endpoints. Five distributions were tested. Ultimately, the results from the vegetative vigor SSDs combining monocots and dicots were used. Table 1provides a summary of the results. Unless otherwise noted, units for application rates are lb a.e./A.

Table 1. Summary statistics for SSD fit to glyphosate test results.

|  |  |
| --- | --- |
| **Statistic** | **Vegetative Vigor** |
| Best Distribution (by AICc) | Triangular |
| Goodness of fit P-value | 0.9950 |
| CV of the HC05 | 0.2358 |
| HC05 | 0.0209 |
| HC10 | 0.0287 |
| HC50 | 0.1110 |
| HC90 | 0.4286 |
| HC95 | 0.5903 |

1. Data

Data used in this analysis are detailed in **Table 6** (at the end of the document) and were from registrant submitted studies as well as an ECOTOX query (**APPENDIX 2-2**). Table 2provides the distribution of the test results for glyphosate including the number of species represented. Distributions were created for terrestrial plants based on IC25 values for various metrics of growth from 21-, 27- and 28-d vegetative vigor studies.

Table 2. Distribution of test results available for glyphosate.

|  |  |  |
| --- | --- | --- |
| **Data Subset** | **Test results** | **Species** |
| Vegetative Vigor | 67 | 36 |

**Figure 1** shows the distribution of test results among species from the vegetative vigor studies. Several species have been repeatedly tested (up to six times), but the majority of species have been tested fewer than three times, with 20 species having only one test result.

 

**Figure 1. Distribution of the number of test results per species in glyphosate vegetative vigor data.**

Five potential distributions for the glyphosate data were considered, including log-normal, log-logistic, log-triangular, log-gumbel, and Burr. To fit each of the first four distributions, the toxicity values were first common log (log10) transformed. Finally, effect thresholds and five quantiles from the fitted SSDs (HC05, HC10, HC50, HC90, HC95) were calculated and reported.

1. Comparison of distributions using AICc

Akaike’s Information Criterion corrected for sample size (AICc) was used to compare the five distributions for the aquatic plant dataset. For these comparisons all SSDs were fit using maximum likelihood. The AICc suggested that the triangular distribution provided the best fit for the vegetative vigor data (Table 3).

Table 3. Comparison of distributions for vegetative vigor toxicity data for glyphosate.

| **distribution** | **AICc** | **∆AICc** | **Weight** | **HC05** |
| --- | --- | --- | --- | --- |
| triangular | -51.3071 | 0 | 0.5276 | 0.0209 |
| normal | -49.9742 | 1.3329 | 0.2709 | 0.0215 |
| logistic | -48.5158 | 2.7913 | 0.1307 | 0.0201 |
| burr | -46.2101 | 5.0970 | 0.0413 | 0.0215 |
| gumbel | -45.5448 | 5.7623 | 0.0296 | 0.0235 |

1. Goodness of fit

The plot of the cumulative distribution functions for the best-fit distributions (as determined by AICc) suggest little evidence of lack-of-fit (**Figure 2**). Bootstrap goodness-of-fit tests did not show evidence for lack-of-fit (P-values > 0.05, Table 4) for any of the distributions. The coefficient of variation for the HC05 was below 1 for all distributions.



**Figure 2. Log-normal SSD for glyphosate toxicity values for terrestrial plants at the vegetative vigor life stage.** Black points indicate single toxicity values. Red points indicate average of multiple toxicity values for a single species. Blue line indicates full range of toxicity values for a given taxon.

Table 4. Range of HC05 values for glyphosate SSDs for terrestrial plants at the vegetative vigor life stage.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Distribution** | **Method** | **HC05** | **SE** | **CV** | **Lower CI** | **Upper CI** | **P** |
| Normal | ML | 0.0242 | 0.0066 | 0.2717 | 0.015 | 0.0407 | 0.8132 |
| Normal | MO | 0.0237 | 0.0063 | 0.2657 | 0.0143 | 0.0386 | 0.7802 |
| Normal | GR | 0.0213 | 0.0061 | 0.2844 | 0.0108 | 0.0346 | 0.6424 |
| Logistic | ML | 0.0234 | 0.0071 | 0.3052 | 0.0132 | 0.0415 | 0.6683 |
| Logistic | MO | 0.0242 | 0.007 | 0.2893 | 0.0131 | 0.0394 | 0.8002 |
| Logistic | GR | 0.0203 | 0.0058 | 0.287 | 0.0089 | 0.0318 | 0.8002 |
| Triangular | ML | 0.0235 | 0.0063 | 0.2672 | 0.0177 | 0.0414 | 0.0629 |
| Triangular | MO | 0.023 | 0.0058 | 0.2536 | 0.0142 | 0.0373 | 0.5784 |
| Triangular | GR | 0.022 | 0.0057 | 0.2583 | 0.0129 | 0.0354 | 0.4745 |
| Gumbel | ML | 0.0282 | 0.0051 | 0.1828 | 0.0209 | 0.0409 | 0.2607 |
| Gumbel | MO | 0.0333 | 0.0066 | 0.199 | 0.0227 | 0.0489 | 0.2787 |
| Gumbel | GR | 0.0302 | 0.0061 | 0.2022 | 0.0177 | 0.0408 | 0.3077 |
| Burr | ML | 0.0264 | 0.0082 | 0.3117 | 0.0146 | 0.0463 | 0.5764 |

ML=maximum likelihood, MO= moment estimators, and GR=graphical methods

LCp and UCp=projections of the confidence limits of the HC05 (LCx and UCx) onto the cumulative distribution function of the fitted distribution.

1. Calculation of other quantiles

Table 5 provides estimates of the HC05 as well as other quantiles of the fitted SSDs.

Table 5. Estimated quantiles of the fitted SSDs for glyphosate IC25s for terrestrial plants at the vegetative vigor life stage.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Distribution** | **Method** | **HC05** | **HC10** | **HC50** | **HC90** | **HC95** |
| Normal | ML | 0.0242 | 0.0347 | 0.1233 | 4.38E-01 | 6.27E-01 |
| Normal | MO | 0.0237 | 0.0341 | 0.1233 | 4.46E-01 | 6.41E-01 |
| Normal | GR | 0.0213 | 0.0314 | 0.1233 | 4.83E-01 | 7.12E-01 |
| Logistic | ML | 0.0234 | 0.0355 | 0.1207 | 4.10E-01 | 6.22E-01 |
| Logistic | MO | 0.0242 | 0.0366 | 0.1233 | 4.15E-01 | 6.28E-01 |
| Logistic | GR | 0.0203 | 0.032 | 0.1233 | 4.74E-01 | 7.50E-01 |
| Triangular | ML | 0.0235 | 0.0335 | 0.1502 | 6.73E-01 | 9.59E-01 |
| Triangular | MO | 0.023 | 0.0317 | 0.1233 | 4.79E-01 | 6.61E-01 |
| Triangular | GR | 0.022 | 0.0306 | 0.1233 | 4.96E-01 | 6.90E-01 |
| Gumbel | ML | 0.0282 | 0.0357 | 0.1062 | 5.86E-01 | 1.13E+00 |
| Gumbel | MO | 0.0333 | 0.0409 | 0.1045 | 4.56E-01 | 8.00E-01 |
| Gumbel | GR | 0.0302 | 0.0378 | 0.1061 | 5.35E-01 | 9.93E-01 |
| Burr | ML | 0.0264 | 0.0374 | 0.1173 | 4.39E-01 | 7.01E-01 |

Table 6provides the IC25 values included in the SSD for vegetative vigor. If a species was not represented with a 96 hour study, and other values were available from shorter/longer duration studies (up to 10 days) then the data were included. If there were multiple other durations, the value from the study closer to a 96h duration was selected and if there were multiple values for the same duration, all values are presented.

Table 6. Nontarget Terrestrial Plant Vegetative Vigor Toxicity (Tier II). All definitive endpoints are used quantitatively in the SSD.

|  |  |  |
| --- | --- | --- |
| **Genus** | **species** | **IC25** |
| Abelmoschus | esculentus | 0.17 |
| Allium | cepa | 0.28 |
| Andropogon | gerardii | 0.034 |
| Asclepias | syriaca | 0.051 |
| Avena | sativa | 0.036 |
| Bellis | perennis | 0.039 |
| Bellis | perennis | 0.044 |
| Beta | vulgaris | 0.21 |
| Beta | vulgaris | 0.28 |
| Carex | comosa | 0.23 |
| Centaurea | cyanus | 0.14 |
| Centaurea | cyanus | 0.15 |
| Cucumis | sativus | 0.45 |
| Cyperus | rotundus | 0.81 |
| Digitalis | purpurea | 0.068 |
| Digitalis | purpurea | 0.10 |
| Digitalis | purpurea | 0.15 |
| Elymus | lanceolatus | 0.044 |
| Fragaria | virginiana | 0.049 |
| Fragaria | x ananassa | 0.023 |
| Geum | canadense | 0.028 |
| Geum | canadense | 0.30 |
| Glycine | max | 0.054 |
| Glycine | max | 0.13 |
| Glycine | max | 0.32 |
| Helianthus | annus | 0.16 |
| Inula | helenium | 0.066 |
| Lactuca | canadensis | 0.093 |
| Lactuca | sativa | 0.0021 |
| Lactuca | sativa | 0.0048 |
| Lactuca | sativa | 0.070 |
| Lactuca | sativa | 0.22 |
| Lactuca | sativa | 0.27 |
| Lactuca | sativa | 0.52 |
| Leucanthemum | vulgare | 0.075 |
| Leucanthemum | vulgare | 0.54 |
| Leucanthemum | vulgare | 0.64 |
| Leucanthemum | vulgare | 0.83 |
| Lycopus | americanus | 0.038 |
| Lycopus | americanus | 0.057 |
| Lycopus | americanus | 0.093 |
| Pisum | sativum | 0.89 |
| Poa | compressa | 0.018 |
| Pontederia | cordata | 0.47 |
| Prunella | vulgaris | 0.13 |
| Prunella | vulgaris | 0.14 |
| Raphanus | sativus | 0.067 |
| Raphanus | sativus | 0.09 |
| Rudbeckia | hirta | 0.036 |
| Rudbeckia | hirta | 0.35 |
| Rudbeckia | hirta | 0.86 |
| Rudbeckia | hirta | 0.93 |
| Rumex | crispus | 0.24 |
| Rumex | crispus | 0.27 |
| Rumex | crispus | 0.42 |
| Solanum | lycopersicum | 0.0029 |
| Solanum | lycopersicum | 0.022 |
| Solanum | lycopersicum | 0.034 |
| Solidago | canadensis | 0.16 |
| Sorghum | bicolor | 0.16 |
| Triticum | aestivum | 0.013 |
| Triticum | aestivum | 0.18 |
| Triticum | aestivum | 0.22 |
| Vicia | americana | 0.093 |
| Zea | mays | 0.071 |
| Zea | mays | 0.35 |