**Herbicide Evaluation on Transplanted Brussels Sprout and Kale**

Trials 2020.04 & 2020.05

Steve A. Fennimore and John S. Rachuy; University of California-Davis

Small acreage Brassica vegetables need additional herbicide options. Among the vegetables grown in California are a number of niche crops such as Bok choi and Brussels sprouts that have a limited number of registered herbicides such as DCPA (Dacthal, Anonymous 2019a). Sulfentrazone (Zeus) now has a food use tolerance for use on Brassica head and stem group 5-16, which includes crops such as Bok choi and Brussels sprouts as well as Brassica leafy greens subgroup 4-16B, consisting of crops such as mustard greens (USEPA 2017; USEPA 2018). However, there is a lack of data for Zeus on a wide variety of Brassica vegetables, and the objective of this work was to gather crop tolerance data for Zeus on kale and Brussels sprouts.

Transplanted kale and Brussels sprouts were treated with Zeus at 0.047, 00.07 and .094 lbs. ai/A, oxyfluorfen (GoalTender) at 0.125, 0.25 and 0.5 lbs. ai/A and *S*-metolachlor (Dual Magnum) at 0.33, 0.5 and 0.65 lbs. ai/A at pre-transplant (PRE); Dual Magnum at 0.33, 0.5 and 0.65 lbs. ai/A at post-transplant/pre-emergence (POST); and pyridate (Tough) at 0.47 and 0.62 lbs. ai/A + NIS at 0.25% v/v post-transplant prior to the weeds reaching 3” (POST). The standard was Dacthal PRE at 7.5 lbs. ai/A. A non-treated control was included. The trial was conducted at Salinas, CA during July to December 2020 (Table 1). Treatments were replicated 4 times and arranged in a randomized complete block design. Data collected were crop injury estimates, stand and yield, as well as weed control. Data were subjected to analysis of variance using Agricultural Research Manager and mean separation was performed using LSD’s.

**Results.**

Dacthal, Dual Magnum, Goaltender and Zeus caused little or no injury to kale or Brussels sprouts (Tables 2 and 3). Pyridate at 0.47 lbs. ai/A caused very slight (<2 rating) injury to kale and Brussels sprouts from which both crops quickly recovered. Pyridate at 0.62 lbs. ai/A caused minor injury to kale and Brussels sprouts, from which both crops quickly recovered. None of the treatments reduced stand or yield of kale or Brussels sprouts (Tables 4, 5, 6).

Weeds present were common purslane, burning nettle and shepherd’s-purse (Table 7). Zeus and GoalTender were effective on burning nettle and shepherds-purse. Zeus at 0.07 and 0.094, and GoalTender at 0.25 and 0.5 lbs. ai/A were highly effective on purslane. Dual Magnum Pre-Transplant was effective on burning nettle and shepherds-purse but poor on purslane. Dual Magnum POST 0.65 lb ai/A was moderately effective on shepherds-purse and burning nettle but poor on purslane. Pyridate + NIS was highly effective on burning nettle and shepherd’s-purse, but provided no control of purslane. Dacthal was highly effective on burning nettle and shepherds-purse, but provided partial control of common purslane.

**Table 1**. Critical trial events and dates

|  |  |  |
| --- | --- | --- |
| **Critical Event** | **Date / Information** | |
| Trial No.: | 2020.04 | 2020.05 |
| Crop: | Kale | Brussels Sprout |
| Transplanting Date: | 7/16/20 | 7/30/20 |
| Cultivar: | Black Magic | Confidant |
| Application Intervals: | | |
| Pre-Transplant: | 7/15/20 | 7/29/20 |
| Post Trans/Pre-Emergent: | 7/21/20 | 8/4/20 |
| Post Trans @ <3” Weeds: | 7/29/20 | 8/11/20 |
| Evaluations: | | |
| Weed Counts: | 8/4/20 | 8/17/20 |
| Crop Injury:  PRE Treatments  POST Dual Magnum Treatments  POST Pyridate Treatments | 7/30/20 14-DATp  8/13/20 28-DATp  8/27/20 42-DATp  7/24/20 3-DATr  7/28/20 7-DATr  8/4/20 14-DATr  8/3/20 5-DATr  8/6/20 8-DATr  8/12/20 14-DATr | 8/13/20 14-DATp  8/27/20 28-DATp  9/10/20 42-DATp  8/7/20 3-DATr  8/11/20 7-DATr  8/18/20 14-DATr  8/14/20 3-DATr  8/18/20 7-DATr  8/25/20 14-DATr |
| Crop Stand:  PRE Treatments  POST Dual Magnum Treatments  POST Pyridate Treatments | 8/13/20 28-DATp  8/4/20 14-DATr  8/12/20 14-DATr | 8/27/20 28-DATp  8/18/20 14-DATr  8/25/20 14-DATr |
| Yield (Fresh Weight): | 9/9/20 | 12/8-10/20 |

DATp = Days after Transplant

DATr = Days after Treatment

**Table 2**. Kale crop injury estimates**¹**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Rate**  **(lbs. ai/A)** | **Timing** | **JUL 30**  **14-DATp** | **AUG 13**  **28-DATp** | **AUG 27**  **42-DATp** | **JUL 24**  **3-DATr** | **JUL 28**  **7-DATr** | **AUG 4**  **14DATr** | **AUG 3**  **5-DATr** | **AUG 6**  **8-DATr** | **AUG 12**  **14DATr** | **All Trts**  **14DAT** |
| **0 – 10 Scale** | | | | | | | | | | |
| NonTreated | 0 | --- | 0.0 | 0.0 c | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 c | 0.0 c | 0.0 c | 0.0 c |
| Dacthal | 7.5 | PRE | 0.6 | 0.1 bc | 0.1 | --- | --- | --- | --- | --- | --- | 0.6 abc |
| Zeus | 0.047 | PRE | 0.0 | 0.0 c | 0.0 | --- | --- | --- | --- | --- | --- | 0.0 c |
| Zeus | 0.07 | PRE | 0.0 | 0.0 c | 0.0 | --- | --- | --- | --- | --- | --- | 0.0 c |
| Zeus | 0.094 | PRE | 0.4 | 0.5 abc | 0.3 | --- | --- | --- | --- | --- | --- | 0.4 bc |
| GoalTender | 0.125 | PRE | 0.3 | 0.4 bc | 0.3 | --- | --- | --- | --- | --- | --- | 0.3 bc |
| GoalTender | 0.25 | PRE | 0.0 | 0.0 c | 0.0 | --- | --- | --- | --- | --- | --- | 0.0 c |
| GoalTender | 0.5 | PRE | 0.6 | 0.5 abc | 0.1 | --- | --- | --- | --- | --- | --- | 0.6 abc |
| Dual Magnum | 0.33 | PRE | 0.5 | 0.8 ab | 0.1 | --- | --- | --- | --- | --- | --- | 0.5 bc |
| Dual Magnum | 0.5 | PRE | 0.0 | 0.8 ab | 0.4 | --- | --- | --- | --- | --- | --- | 0.0 c |
| Dual Magnum | 0.65 | PRE | 0.6 | 1.1 a | 0.3 | --- | --- | --- | --- | --- | --- | 0.6 abc |
| Dual Magnum | 0.33 | POST | --- | --- | --- | 0.0 | 0.0 | 0.6 | --- | --- | --- | 0.6 abc |
| Dual Magnum | 0.5 | POST | --- | --- | --- | 0.0 | 0.0 | 0.0 | --- | --- | --- | 0.0 c |
| Dual Magnum | 0.65 | POST | --- | --- | --- | 0.4 | 0.3 | 0.0 | --- | --- | --- | 0.0 c |
| Pyridate +  X-77 NIS | 0.47 +  0.25% v/v | POST | --- | --- | --- | --- | --- | --- | 1.9 b | 1.8 b | 0.8 b | 0.8 ab |
| Pyridate +  X-77 NIS | 0.62 +  0.25% v/v | POST | --- | --- | --- | --- | --- | --- | 2.4 a | 2.3 a | 1.3 a | 1.3 a |
| LSD (P = .05) | | | 0.74 | 0.71 | 0.45 | 0.38 | 0.23 | 0.60 | 0.25 | 0.50 | 0.50 | 0.70 |
| Treatment Prob (F) | | | 0.3199 | 0.0252 | 0.7044 | 0.1298 | 0.0877 | 0.1025 | 0.0001 | 0.0001 | 0.0025 | 0.0121 |

**¹** Rating scale: 0 = no injury, ≤2=safe, 10 = complete crop death.

**Table 3**. Brussels Sprout crop injury estimates**¹**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Rate**  **(lbs. ai/A)** | **Timing** | **AUG 13**  **14-DATp** | | **AUG 27**  **28-DATp** | | **SEP 10**  **42-DATp** | | **AUG 7**  **3-DATr** | | **AUG 11**  **7-DATr** | | **AUG 18**  **14DATr** | | **AUG 14**  **3-DATr** | | **AUG 18**  **7-DATr** | | **AUG 25**  **14DATr** | | **All Trts**  **14DAT** | |
| **0 – 10 Scale** | | | | | | | | | | | | | | | | | | | |
| NonTreated | 0 | --- | 0.0 | | 0.0 b | | 0.0 c | | 0.0 | | 0.0 | | 0.0 | | 0.0 c | | 0.0 c | | 0.0 c | | 0.0 | |
| Dacthal | 7.5 | PRE | 0.0 | | 0.3 b | | 0.1 bc | | --- | | --- | | --- | | --- | | --- | | --- | | 0.0 | |
| Zeus | 0.047 | PRE | 0.0 | | 0.3 b | | 0.1 bc | | --- | | --- | | --- | | --- | | --- | | --- | | 0.0 | |
| Zeus | 0.07 | PRE | 0.0 | | 0.1 b | | 0.5 abc | | --- | | --- | | --- | | --- | | --- | | --- | | 0.0 | |
| Zeus | 0.094 | PRE | 0.0 | | 0.8 a | | 0.9 a | | --- | | --- | | --- | | --- | | --- | | --- | | 0.0 | |
| GoalTender | 0.125 | PRE | 0.0 | | 0.1 b | | 0.3 abc | | --- | | --- | | --- | | --- | | --- | | --- | | 0.0 | |
| GoalTender | 0.25 | PRE | 0.0 | | 0.1 b | | 0.8 ab | | --- | | --- | | --- | | --- | | --- | | --- | | 0.0 | |
| GoalTender | 0.5 | PRE | 0.0 | | 0.4 ab | | 0.9 a | | --- | | --- | | --- | | --- | | --- | | --- | | 0.0 | |
| Dual Magnum | 0.33 | PRE | 0.0 | | 0.0 b | | 0.0 c | | --- | | --- | | --- | | --- | | --- | | --- | | 0.0 | |
| Dual Magnum | 0.5 | PRE | 0.0 | | 0.0 b | | 0.0 c | | --- | | --- | | --- | | --- | | --- | | --- | | 0.0 | |
| Dual Magnum | 0.65 | PRE | 0.0 | | 0.0 b | | 0.3 abc | | --- | | --- | | --- | | --- | | --- | | --- | | 0.0 | |
| Dual Magnum | 0.33 | POST | --- | | --- | | --- | | 0.0 | | 0.0 | | 0.0 | | --- | | --- | | --- | | 0.0 | |
| Dual Magnum | 0.5 | POST | --- | | --- | | --- | | 0.0 | | 0.0 | | 0.0 | | --- | | --- | | --- | | 0.0 | |
| Dual Magnum | 0.65 | POST | --- | | --- | | --- | | 0.1 | | 0.0 | | 0.0 | | --- | | --- | | --- | | 0.0 | |
| Pyridate +  X-77 NIS | 0.47 +  0.25% v/v | POST | --- | | --- | | --- | | --- | | --- | | --- | | 1.3 b | | 1.3 b | | 0.6 b | | 0.6 b | |
| Pyridate +  X-77 NIS | 0.62 +  0.25% v/v | POST | --- | | --- | | --- | | --- | | --- | | --- | | 2.1 a | | 2.1 a | | 1.1 a | | 1.1 a | |
| LSD (P = .05) | | | 0.00 | 0.38 | | 0.63 | | 0.20 | | 0.00 | | 0.00 | | 0.32 | | 0.32 | | 0.38 | | 0.13 | |
| Treatment Prob (F) | | | 1.0000 | 0.0109 | | 0.0223 | | 0.4363 | | 1.0000 | | 1.0000 | | 0.0001 | | 0.0001 | | 0.0011 | | 0.0001 | |

**¹** Rating scale: 0 = no injury, ≤2=safe, 10 = complete crop death.

**Table 4.** Kale and Brussels sprouts crop stand

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Rate**  **(lbs. ai/A)** | **Timing** | **Kale** | | | | **Brussels sprouts** | | | |
| **AUG 13**  **28-DATp** | **AUG 4**  **14DATr** | **AUG 12**  **14DATr** | **All Trts** | **AUG 27**  **28-DATp** | **AUG 18**  **14DATr** | **AUG 25**  **14DATr** | **All Trts** |
| **no./20’ bed** | | | | | | | |
| NonTreated | 0 | --- | 41.5 | 42.0 | 42.0 | 41.5 | 39.3 | 39.3 | 39.3 | 39.3 |
| Dacthal | 7.5 | PRE | 40.8 | --- | --- | 40.8 | 40.0 | --- | --- | 40.0 |
| Zeus | 0.047 | PRE | 40.8 | --- | --- | 40.8 | 40.5 | --- | --- | 40.5 |
| Zeus | 0.07 | PRE | 42.0 | --- | --- | 42.0 | 39.8 | --- | --- | 39.8 |
| Zeus | 0.094 | PRE | 41.0 | --- | --- | 41.0 | 40.3 | --- | --- | 40.3 |
| GoalTender | 0.125 | PRE | 40.5 | --- | --- | 40.5 | 40.5 | --- | --- | 40.5 |
| GoalTender | 0.25 | PRE | 40.3 | --- | --- | 40.3 | 39.8 | --- | --- | 39.8 |
| GoalTender | 0.5 | PRE | 41.5 | --- | --- | 41.5 | 40.0 | --- | --- | 40.0 |
| Dual Magnum | 0.33 | PRE | 41.0 | --- | --- | 41.0 | 40.5 | --- | --- | 40.5 |
| Dual Magnum | 0.5 | PRE | 41.3 | --- | --- | 41.3 | 40.0 | --- | --- | 40.0 |
| Dual Magnum | 0.65 | PRE | 42.5 | --- | --- | 42.5 | 39.8 | --- | --- | 39.8 |
| Dual Magnum | 0.33 | POST | --- | 41.5 | --- | 41.5 | --- | 40.3 | --- | 40.3 |
| Dual Magnum | 0.5 | POST | --- | 40.5 | --- | 40.5 | --- | 38.8 | --- | 38.8 |
| Dual Magnum | 0.65 | POST | --- | 40.5 | --- | 40.5 | --- | 39.0 | --- | 39.0 |
| Pyridate +  X-77 NIS | 0.47 +  0.25% v/v | POST | --- | --- | 41.8 | 41.8 | --- | --- | 40.3 | 40.3 |
| Pyridate +  X-77 NIS | 0.62 +  0.25% v/v | POST | --- | --- | 41.3 | 41.3 | --- | --- | 40.0 | 40.0 |
| LSD (P = .05) | | | 1.58 | 2.29 | 0.74 | 1.56 | 1.62 | 1.81 | 1.71 | 1.54 |
| Treatment Prob (F) | | | 0.2036 | 0.3889 | 0.1121 | 0.2529 | 0.8800 | 0.3198 | 0.3877 | 0.5202 |

**Table 5**. Kale crop yield (stand, fresh weight and size) at harvest (9/9/20)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment** | **Rate**  **(lbs. ai/A)** | **Timing** | **Stand** | **Fresh Weight** | **Size** |
| **(1000s/Ac)** | **(Tons/Ac)** | **(gm/plant)** |
| NonTreated | 0 | --- | 28.0 | 9.9 | 321 |
| Dacthal | 7.5 | PRE | 26.6 | 8.6 | 299 |
| Zeus | 0.047 | PRE | 25.7 | 9.2 | 321 |
| Zeus | 0.07 | PRE | 27.1 | 10.1 | 336 |
| Zeus | 0.094 | PRE | 27.1 | 8.9 | 298 |
| GoalTender | 0.125 | PRE | 28.0 | 9.8 | 318 |
| GoalTender | 0.25 | PRE | 26.6 | 9.0 | 306 |
| GoalTender | 0.5 | PRE | 26.1 | 9.1 | 315 |
| Dual Magnum | 0.33 | PRE | 27.5 | 9.0 | 295 |
| Dual Magnum | 0.5 | PRE | 28.0 | 9.1 | 295 |
| Dual Magnum | 0.65 | PRE | 27.1 | 9.3 | 309 |
| Dual Magnum | 0.33 | POST | 27.1 | 8.6 | 287 |
| Dual Magnum | 0.5 | POST | 27.1 | 8.7 | 290 |
| Dual Magnum | 0.65 | POST | 26.6 | 8.2 | 276 |
| Pyridate +  X-77 NIS | 0.47 +  0.25% v/v | POST | 27.5 | 9.5 | 315 |
| Pyridate +  X-77 NIS | 0.62 +  0.25% v/v | POST | 26.1 | 8.7 | 301 |
| LSD (P = .05) | | | 1.86 | 1.89 | 61.2 |
| Treatment Prob (F) | | | 0.3385 | 0.8323 | 0.9152 |

**Table 6**. Brussels sprout crop yield (stand, fresh weight and size) at harvest (12/10/20)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment** | **Rate**  **(lbs. ai/A)** | **Timing** | **Stand** | **Fresh Weight** | **Size** |
| **(1000s/Ac)** | **(Tons/Ac)** | **(gm/plant)** |
| NonTreated | 0 | --- | 28.5 | 6.0 | 190 |
| Dacthal | 7.5 | PRE | 29.4 | 5.8 | 180 |
| Zeus | 0.047 | PRE | 28.0 | 5.7 | 185 |
| Zeus | 0.07 | PRE | 27.1 | 6.0 | 201 |
| Zeus | 0.094 | PRE | 25.7 | 6.3 | 225 |
| GoalTender | 0.125 | PRE | 28.5 | 5.3 | 169 |
| GoalTender | 0.25 | PRE | 27.1 | 5.8 | 194 |
| GoalTender | 0.5 | PRE | 28.5 | 5.7 | 183 |
| Dual Magnum | 0.33 | PRE | 28.5 | 5.4 | 173 |
| Dual Magnum | 0.5 | PRE | 26.6 | 5.5 | 190 |
| Dual Magnum | 0.65 | PRE | 28.0 | 5.7 | 184 |
| Dual Magnum | 0.33 | POST | 28.9 | 5.5 | 173 |
| Dual Magnum | 0.5 | POST | 27.1 | 5.3 | 179 |
| Dual Magnum | 0.65 | POST | 27.5 | 6.0 | 201 |
| Pyridate +  X-77 NIS | 0.47 +  0.25% v/v | POST | 28.5 | 5.8 | 184 |
| Pyridate +  X-77 NIS | 0.62 +  0.25% v/v | POST | 28.0 | 6.0 | 195 |
| LSD (P = .05) | | | 2.30 | 0.99 | 38.7 |
| Treatment Prob (F) | | | 0.1817 | 0.8100 | 0.4598 |

**Table 7**. Weed control (density)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Rate**  **(lbs. ai/A)** | **Timing** | **Kale** | | | **Brussels sprouts** | | |
| **Purslane** | **Burning Nettle** | **Total Weeds** | **Burning Nettle** | **Shepherds-**  **Purse** | **Total Weeds** |
| **Weed Density (No./2.8ft²)** | | | | | |
| NonTreated | 0 | --- | 37.1 ab | 26.4 a | 73.0 a | 19.4 a | 17.9 a | 52.1 a |
| Dacthal | 7.5 | PRE | 20.1 cd | 5.9 cde | 37.1 bc | 1.8 c | 8.6 b | 36.6 abc |
| Zeus | 0.047 | PRE | 30.4 bc | 2.5 de | 43.5 b | 1.0 c | 5.9 b-e | 16.9 def |
| Zeus | 0.07 | PRE | 13.0 de | 0.6 de | 20.0 de | 0.5 c | 1.6 de | 9.0 ef |
| Zeus | 0.094 | PRE | 11.1 de | 2.3 de | 24.3 cd | 0.1 c | 0.9 e | 5.3 f |
| GoalTender | 0.125 | PRE | 20.1 cd | 3.4 de | 29.9 bcd | 2.5 c | 6.3 b-e | 19.8 c-f |
| GoalTender | 0.25 | PRE | 6.4 e | 1.0 de | 15.0 de | 0.9 c | 4.9 b-e | 20.8 c-f |
| GoalTender | 0.5 | PRE | 3.0 e | 0.3 e | 7.0 e | 1.4 c | 4.5 b-e | 11.0 ef |
| Dual Magnum | 0.33 | PRE | 27.3 bc | 9.9 bcd | 44.3 b | 6.8 bc | 7.6 bc | 26.4 cde |
| Dual Magnum | 0.5 | PRE | 28.8 bc | 5.9 cde | 43.6 b | 2.0 c | 2.8 cde | 16.8 def |
| Dual Magnum | 0.65 | PRE | 21.5 cd | 7.8 cde | 39.5 bc | 2.4 c | 3.0 b-e | 12.0 ef |
| Dual Magnum | 0.33 | POST | 47.1 a | 14.9 bc | 73.4 a | 17.0 ab | 6.8 bcd | 45.1 ab |
| Dual Magnum | 0.5 | POST | 30.9 bc | 18.5 ab | 63.4 a | 9.5 abc | 4.9 b-e | 31.4 bcd |
| Dual Magnum | 0.65 | POST | 21.5 cd | 8.0 cde | 43.9 b | 2.3 c | 5.8 b-e | 35.4 abc |
| Pyridate +  X-77 NIS | 0.47 +  0.25% v/v | POST | 37.1 ab | 1.6 de | 41.0 b | 0.5 c | 2.5 cde | 11.6 ef |
| Pyridate +  X-77 NIS | 0.62 +  0.25% v/v | POST | 34.3 b | 1.0 de | 38.5 bc | 0.3 c | 2.5 cde | 11.9 ef |
| LSD (P = .05) | | | 12.1 | 9.5 | 16.6 | 10.5 | 5.7 | 17.6 |
| Treatment Prob (F) | | | 0.0001 | 0.0001 | 0.0001 | 0.0058 | 0.0002 | 0.0001 |