The seed column before post-harvest tillage was transitioned from post-harvest tillage through spring tillage with the general form of by Caswell (2001).

### Write the top stratum of the newly shuffled seed columns (from fall tillage through spring tillage) into a dummy matrix  
# https://community.rstudio.com/t/extract-matrix-rows-from-list/19357/2  
#https://stackoverflow.com/questions/29511215/convert-row-names-into-first-column  
  
mean\_after\_spring\_tillage\_pop\_scenario1\_top\_stratum\_df <- mean\_after\_spring\_tillage\_pop\_scenario1 %>%  
 map(~.x[1, ]) %>%   
 unlist(use.names = TRUE) %>%  
 as.data.frame() %>%  
 rownames\_to\_column("matrix\_id") %>%   
 rename(top\_stratum\_density = ".") %>%  
 mutate(top\_stratum\_female\_density = top\_stratum\_density/2) #assume 1:1 male:female  
  
  
#mean\_after\_spring\_tillage\_pop\_scenario1\_dummy <- lapply(split(mean\_after\_spring\_tillage\_pop\_scenario1\_df, mean\_after\_spring\_tillage\_pop\_scenario1\_df$matrix\_id),  
# function(x)(matrix(x$top\_stratum\_density, nrow = 6)))  
  
mean\_after\_spring\_tillage\_pop\_scenario1\_bottom\_stratum\_df <- mean\_after\_spring\_tillage\_pop\_scenario1 %>%  
 map(~.x[2, ]) %>%   
 unlist(use.names = TRUE) %>%  
 as.data.frame() %>%  
 rownames\_to\_column("matrix\_id") %>%   
 rename(bottom\_stratum\_density = ".") %>%  
 mutate(bottom\_stratum\_female\_density = bottom\_stratum\_density/2)

**include in the matrix assembly section**

5% of the waterhemp seeds in a soil seedbank of 5 cm deep that was undisturbed mechanically in the first burial year and unexposed to herbicides throughout the experiment, emerged a year after seed burial (Buhler and Hartzler 2001). Annually, 23.5% +/- 16.6% sd of waterhemp seeds that were not treated with herbicides and undisturbed mechanically emerged from the top 1 cm soil layer (Schutte and Davis 2014).

Mesotrione applied at 75 g ha rate was 76% and 96% efficacious against *A retroflexus* L grown in corn that were susceptible and resistant to atrazine, respectively (**sutton2002activity?**). On average, the Thiencarbazone-methyl + isoxaflutole mixture was 93.5% efficacious and mesotrione was 70.75% efficacious against *A. palmeri* grown in corn (**janak2016weed?**).

We combined the findings on other *Amaranthus* species from (**sutton2002activity?**); (**janak2016weed?**) for herbicide efficacy and from Buhler and Hartzler (2001) and Schutte and Davis (2014) for herbicide-unexposed germinants’ emergence and set a uniform germination rate in all the crop identity crossed with corn weed management at 20%. The remaining seedbank density in the 0 - 2 cm soil stratum is calculated using the following equation:

where,  
 is the remaining seedbank density after seed germination is the seed density in the top 0 - 2 cm soil stratum upon completion of pre-planting tillage is the proportion of germinated seeds is the proportion of germinated seeds that successfully emerge as seedlings is the proportion of germinated seeds that were killed by weed control measures

is filled in the [1,1] position of the seedling recruitment matrix ().

The resistance profile of waterhemp at our experiment site was undetermined, but the raw estimation of seedling emergence proportion with respect to the top 0 - 2 cm soil seedbank density seems unrealistically low (Table 1. The cohort-specific emergence rates ( through ) were adjusted from the raw data ( with ) to reflect 5% emergence success rate (equivalent to ) in crop environments that received pre-emergence herbicides (C2, C3 and C4 under conventional weed management and all the S2, S3, and S4 (Table 1, Nguyen and Liebman 2022)), 100% emergence success rate (equivalent to ) in the crop environments that received post-emergence herbicides (C2, C3 and C4 under low herbicide weed management, (Table 1, Nguyen and Liebman 2022)) and 50% emergence success rate (equivalent to ).

Table 1: Estimated and adjusted seedling emergence proportion with respect to the top 0 - 2 cm soil stratum and the whole seedbank (20 cm deep) using 2019 stratified soil seedbank densities and 2020 seedling emergence densities.

|  |  | Estimated total emergence proportion from | |  | Adjusted total emergence proportion from | |
| --- | --- | --- | --- | --- | --- | --- |
| Crop ID | Corn weed management | top 0 - 2 cm | whole seedbank | adjuster | top 0 - 2 cm | whole seedbank |
| C2 | conventional | 0.0024 | 0.0008 | 4.1310 | 0.01 | 0.0031 |
| C2 | low | 0.0109 | 0.0033 | 18.2760 | 0.20 | 0.0606 |
| S2 | conventional | 0.0637 | 0.0179 | 0.1570 | 0.01 | 0.0028 |
| S2 | low | 0.0248 | 0.0086 | 0.4035 | 0.01 | 0.0035 |
| C3 | conventional | 0.0073 | 0.0017 | 1.3686 | 0.01 | 0.0024 |
| C3 | low | 0.0298 | 0.0067 | 6.7167 | 0.20 | 0.0449 |
| S3 | conventional | 0.0374 | 0.0063 | 0.2676 | 0.01 | 0.0017 |
| S3 | low | 0.0234 | 0.0048 | 0.4275 | 0.01 | 0.0021 |
| O3 | conventional | 0.0030 | 0.0005 | 33.1797 | 0.10 | 0.0167 |
| O3 | low | 0.0033 | 0.0005 | 30.3782 | 0.10 | 0.0165 |
| C4 | conventional | 0.0587 | 0.0121 | 0.1704 | 0.01 | 0.0021 |
| C4 | low | 0.1997 | 0.0404 | 1.0016 | 0.20 | 0.0405 |
| S4 | conventional | 0.0010 | 0.0002 | 9.6448 | 0.01 | 0.0018 |
| S4 | low | 0.0011 | 0.0002 | 9.3056 | 0.01 | 0.0019 |
| O4 | conventional | 0.0009 | 0.0004 | 110.0551 | 0.10 | 0.0433 |
| O4 | low | 0.0009 | 0.0004 | 107.2800 | 0.10 | 0.0474 |
| A4 | conventional | 0.3926 | 0.0126 | 0.2547 | 0.10 | 0.0032 |
| A4 | low | 0.3517 | 0.0108 | 0.2843 | 0.10 | 0.0031 |

# Multiply the raw with the adjuster  
female\_emerge\_prop\_20\_adjusted\_df <- female\_emerge\_prop\_20\_adjusted %>%  
 select(matrix\_id, adjuster\_,  
 cohort1\_mean\_prop\_wrt\_top : cohort6\_mean\_prop\_wrt\_top,  
 cohort1\_mean\_prop\_wrt\_whole : cohort6\_mean\_prop\_wrt\_whole) %>%  
 mutate(adjusted\_cohort1\_mean\_prop\_wrt\_top = adjuster\_\*cohort1\_mean\_prop\_wrt\_top,  
 adjusted\_cohort2\_mean\_prop\_wrt\_top = adjuster\_\*cohort2\_mean\_prop\_wrt\_top,  
 adjusted\_cohort3\_mean\_prop\_wrt\_top = adjuster\_\*cohort3\_mean\_prop\_wrt\_top,  
 adjusted\_cohort4\_mean\_prop\_wrt\_top = adjuster\_\*cohort4\_mean\_prop\_wrt\_top,  
 adjusted\_cohort5\_mean\_prop\_wrt\_top = adjuster\_\*cohort5\_mean\_prop\_wrt\_top,  
 adjusted\_cohort6\_mean\_prop\_wrt\_top = adjuster\_\*cohort6\_mean\_prop\_wrt\_top,  
 adjusted\_cohort1\_mean\_prop\_wrt\_whole = adjuster\_\*cohort1\_mean\_prop\_wrt\_whole,  
 adjusted\_cohort2\_mean\_prop\_wrt\_whole = adjuster\_\*cohort2\_mean\_prop\_wrt\_whole,  
 adjusted\_cohort3\_mean\_prop\_wrt\_whole = adjuster\_\*cohort3\_mean\_prop\_wrt\_whole,  
 adjusted\_cohort4\_mean\_prop\_wrt\_whole = adjuster\_\*cohort4\_mean\_prop\_wrt\_whole,  
 adjusted\_cohort5\_mean\_prop\_wrt\_whole = adjuster\_\*cohort5\_mean\_prop\_wrt\_whole,  
 adjusted\_cohort6\_mean\_prop\_wrt\_whole = adjuster\_\*cohort6\_mean\_prop\_wrt\_whole,  
 top\_mean\_remain\_prop = 1 - (adjusted\_cohort1\_mean\_prop\_wrt\_top +  
 adjusted\_cohort2\_mean\_prop\_wrt\_top +   
 adjusted\_cohort3\_mean\_prop\_wrt\_top +  
 adjusted\_cohort4\_mean\_prop\_wrt\_top +   
 adjusted\_cohort5\_mean\_prop\_wrt\_top +   
 adjusted\_cohort6\_mean\_prop\_wrt\_top))  
  
  
### Mean matrix list   
female\_emerge\_prop\_20\_adjusted\_df\_long <- female\_emerge\_prop\_20\_adjusted\_df %>%  
 select(matrix\_id, adjusted\_cohort1\_mean\_prop\_wrt\_top:adjusted\_cohort6\_mean\_prop\_wrt\_top) %>%  
 pivot\_longer(!matrix\_id, names\_to = "Cohort", values\_to = "adjusted\_mean\_emerge\_prop")  
  
  
  
female\_emerge\_prop\_20\_adjusted\_list <- lapply(split(female\_emerge\_prop\_20\_adjusted\_df\_long, female\_emerge\_prop\_20\_adjusted\_df\_long$matrix\_id),  
 function(x) rbind(cbind(matrix(c(0.8, 0,0,1), nrow = 2, byrow = TRUE), matrix(0,nrow = 2, ncol = 6)),  
 cbind(matrix(x$adjusted\_mean\_emerge\_prop, nrow = 6, ncol = 1),matrix(0,nrow =6, ncol=7))))  
  
### Save adjusted emergence list   
# saveRDS(female\_emerge\_prop\_20\_adjusted\_list, file="../2-Data/Clean/adjusted-mean-emergence-prop.RData")

female\_emerge\_prop\_20\_adjusted\_list

## $A4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.8000000000 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0196957501 0 0 0 0 0 0 0  
## [4,] 0.0442930181 0 0 0 0 0 0 0  
## [5,] 0.0003761959 0 0 0 0 0 0 0  
## [6,] 0.0335678394 0 0 0 0 0 0 0  
## [7,] 0.0016212218 0 0 0 0 0 0 0  
## [8,] 0.0004459747 0 0 0 0 0 0 0  
##   
## $A4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.8000000000 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0196449014 0 0 0 0 0 0 0  
## [4,] 0.0438292593 0 0 0 0 0 0 0  
## [5,] 0.0006496612 0 0 0 0 0 0 0  
## [6,] 0.0332841223 0 0 0 0 0 0 0  
## [7,] 0.0018737871 0 0 0 0 0 0 0  
## [8,] 0.0007182687 0 0 0 0 0 0 0  
##   
## $C2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 8.000000e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 8.192085e-04 0 0 0 0 0 0 0  
## [4,] 9.126203e-03 0 0 0 0 0 0 0  
## [5,] 1.364711e-05 0 0 0 0 0 0 0  
## [6,] 1.364711e-05 0 0 0 0 0 0 0  
## [7,] 1.364711e-05 0 0 0 0 0 0 0  
## [8,] 1.364711e-05 0 0 0 0 0 0 0  
##   
## $C2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.800000000 0 0 0 0 0 0 0  
## [2,] 0.000000000 1 0 0 0 0 0 0  
## [3,] 0.027154679 0 0 0 0 0 0 0  
## [4,] 0.136315915 0 0 0 0 0 0 0  
## [5,] 0.012822644 0 0 0 0 0 0 0  
## [6,] 0.009270740 0 0 0 0 0 0 0  
## [7,] 0.007394421 0 0 0 0 0 0 0  
## [8,] 0.007041600 0 0 0 0 0 0 0  
##   
## $C3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 8.000000e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 9.922701e-04 0 0 0 0 0 0 0  
## [4,] 8.814370e-03 0 0 0 0 0 0 0  
## [5,] 9.790507e-06 0 0 0 0 0 0 0  
## [6,] 1.639881e-04 0 0 0 0 0 0 0  
## [7,] 9.790507e-06 0 0 0 0 0 0 0  
## [8,] 9.790507e-06 0 0 0 0 0 0 0  
##   
## $C3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.800000000 0 0 0 0 0 0 0  
## [2,] 0.000000000 1 0 0 0 0 0 0  
## [3,] 0.029273645 0 0 0 0 0 0 0  
## [4,] 0.127406335 0 0 0 0 0 0 0  
## [5,] 0.012067914 0 0 0 0 0 0 0  
## [6,] 0.018882378 0 0 0 0 0 0 0  
## [7,] 0.006186034 0 0 0 0 0 0 0  
## [8,] 0.006183694 0 0 0 0 0 0 0  
##   
## $C4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 8.000000e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 9.614807e-04 0 0 0 0 0 0 0  
## [4,] 8.998794e-03 0 0 0 0 0 0 0  
## [5,] 9.931386e-06 0 0 0 0 0 0 0  
## [6,] 9.931386e-06 0 0 0 0 0 0 0  
## [7,] 9.931386e-06 0 0 0 0 0 0 0  
## [8,] 9.931386e-06 0 0 0 0 0 0 0  
##   
## $C4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.800000000 0 0 0 0 0 0 0  
## [2,] 0.000000000 1 0 0 0 0 0 0  
## [3,] 0.029999699 0 0 0 0 0 0 0  
## [4,] 0.138718132 0 0 0 0 0 0 0  
## [5,] 0.010246571 0 0 0 0 0 0 0  
## [6,] 0.007991206 0 0 0 0 0 0 0  
## [7,] 0.006630544 0 0 0 0 0 0 0  
## [8,] 0.006413847 0 0 0 0 0 0 0  
##   
## $O3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.8000000000 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0207984844 0 0 0 0 0 0 0  
## [4,] 0.0380865465 0 0 0 0 0 0 0  
## [5,] 0.0243725123 0 0 0 0 0 0 0  
## [6,] 0.0155099704 0 0 0 0 0 0 0  
## [7,] 0.0010180758 0 0 0 0 0 0 0  
## [8,] 0.0002144107 0 0 0 0 0 0 0  
##   
## $O3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.8000000000 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0205526989 0 0 0 0 0 0 0  
## [4,] 0.0359709847 0 0 0 0 0 0 0  
## [5,] 0.0237401807 0 0 0 0 0 0 0  
## [6,] 0.0158361598 0 0 0 0 0 0 0  
## [7,] 0.0029116243 0 0 0 0 0 0 0  
## [8,] 0.0009883517 0 0 0 0 0 0 0  
##   
## $O4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.8000000000 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0137987465 0 0 0 0 0 0 0  
## [4,] 0.0389900716 0 0 0 0 0 0 0  
## [5,] 0.0263769079 0 0 0 0 0 0 0  
## [6,] 0.0151215082 0 0 0 0 0 0 0  
## [7,] 0.0052103905 0 0 0 0 0 0 0  
## [8,] 0.0005023752 0 0 0 0 0 0 0  
##   
## $O4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.800000000 0 0 0 0 0 0 0  
## [2,] 0.000000000 1 0 0 0 0 0 0  
## [3,] 0.014320464 0 0 0 0 0 0 0  
## [4,] 0.034929111 0 0 0 0 0 0 0  
## [5,] 0.024610470 0 0 0 0 0 0 0  
## [6,] 0.015402596 0 0 0 0 0 0 0  
## [7,] 0.007294458 0 0 0 0 0 0 0  
## [8,] 0.003442901 0 0 0 0 0 0 0  
##   
## $S2\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.8000000000 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0072150975 0 0 0 0 0 0 0  
## [4,] 0.0018243253 0 0 0 0 0 0 0  
## [5,] 0.0005192177 0 0 0 0 0 0 0  
## [6,] 0.0001950235 0 0 0 0 0 0 0  
## [7,] 0.0001066115 0 0 0 0 0 0 0  
## [8,] 0.0001397245 0 0 0 0 0 0 0  
##   
## $S2\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 8.000000e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 7.733657e-03 0 0 0 0 0 0 0  
## [4,] 1.824108e-03 0 0 0 0 0 0 0  
## [5,] 3.934042e-04 0 0 0 0 0 0 0  
## [6,] 3.801152e-05 0 0 0 0 0 0 0  
## [7,] 5.409597e-06 0 0 0 0 0 0 0  
## [8,] 5.409597e-06 0 0 0 0 0 0 0  
##   
## $S3\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 8.000000e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 7.806923e-03 0 0 0 0 0 0 0  
## [4,] 1.557903e-03 0 0 0 0 0 0 0  
## [5,] 3.869985e-04 0 0 0 0 0 0 0  
## [6,] 3.302373e-05 0 0 0 0 0 0 0  
## [7,] 6.735231e-05 0 0 0 0 0 0 0  
## [8,] 1.477994e-04 0 0 0 0 0 0 0  
##   
## $S3\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 8.000000e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 7.925166e-03 0 0 0 0 0 0 0  
## [4,] 1.555809e-03 0 0 0 0 0 0 0  
## [5,] 3.623558e-04 0 0 0 0 0 0 0  
## [6,] 1.564556e-06 0 0 0 0 0 0 0  
## [7,] 3.655421e-05 0 0 0 0 0 0 0  
## [8,] 1.185505e-04 0 0 0 0 0 0 0  
##   
## $S4\_conv  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 8.000000e-01 0 0 0 0 0 0 0  
## [2,] 0.000000e+00 1 0 0 0 0 0 0  
## [3,] 7.640143e-03 0 0 0 0 0 0 0  
## [4,] 1.545552e-03 0 0 0 0 0 0 0  
## [5,] 3.835362e-05 0 0 0 0 0 0 0  
## [6,] 2.586504e-04 0 0 0 0 0 0 0  
## [7,] 2.586504e-04 0 0 0 0 0 0 0  
## [8,] 2.586504e-04 0 0 0 0 0 0 0  
##   
## $S4\_low  
## [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8]  
## [1,] 0.8000000000 0 0 0 0 0 0 0  
## [2,] 0.0000000000 1 0 0 0 0 0 0  
## [3,] 0.0058966010 0 0 0 0 0 0 0  
## [4,] 0.0018654416 0 0 0 0 0 0 0  
## [5,] 0.0008685319 0 0 0 0 0 0 0  
## [6,] 0.0004189521 0 0 0 0 0 0 0  
## [7,] 0.0004189521 0 0 0 0 0 0 0  
## [8,] 0.0005315212 0 0 0 0 0 0 0

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