Pollen-Mediated Gene Flow from Glyphosate-Resistant to Susceptible Giant Ragweed (*Ambrosia trifida* L.) under Field Conditions

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Introduction

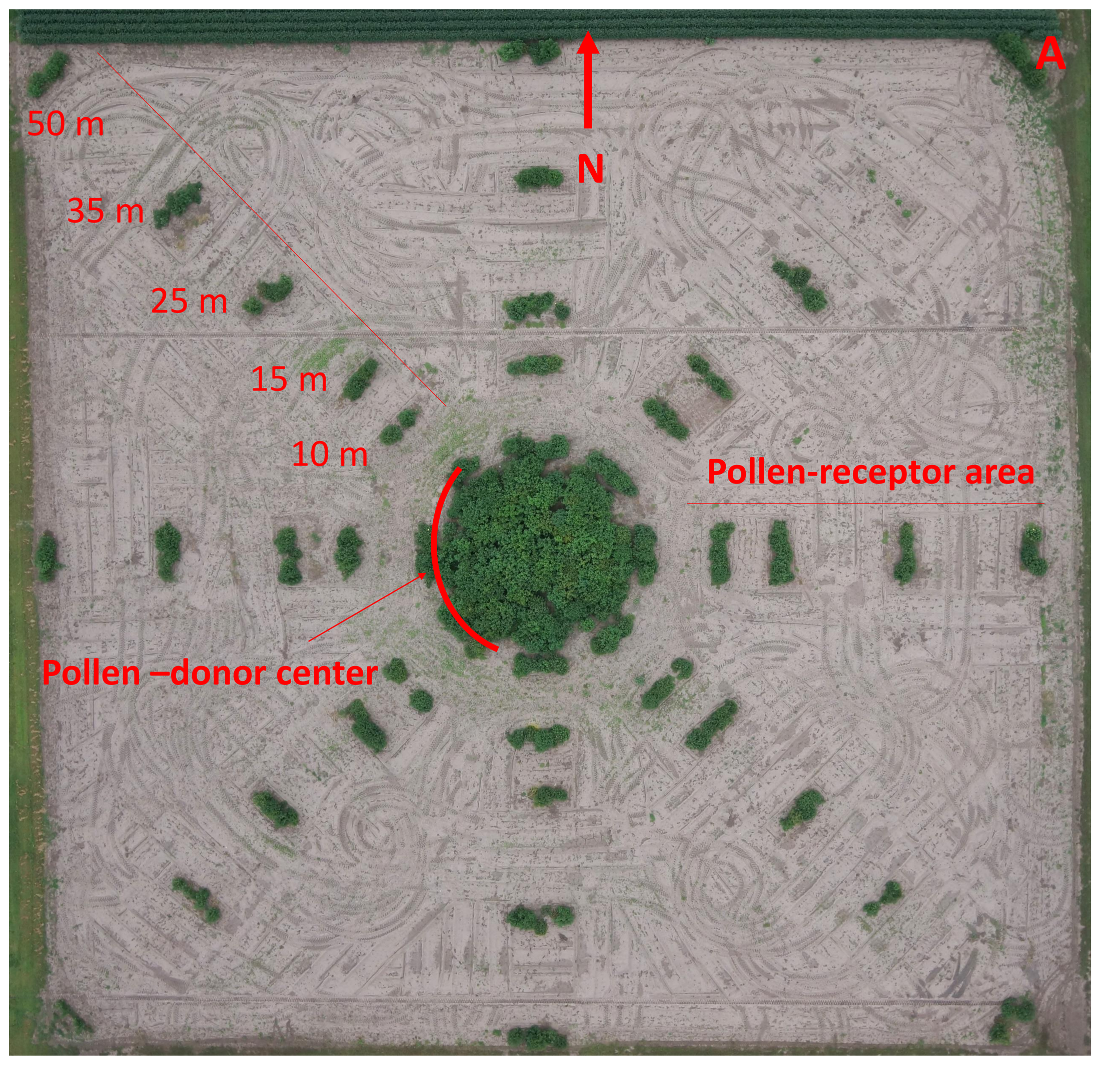
- Glyphosate-resistance is a nuclear inherited dominant or semi-dominant trait and can be used as a marker to detect gene flow (Powles and Preston 2006).
- Giant ragweed is a monoecious species showing considerable outcrossing mainly due to its prolific pollen production (≥10 million pollen grains per day per plant during the peak flowering period) and anemophilous nature.
- Scientific literature is not available on pollen-mediated gene flow from glyphosate-resistant giant ragweed under field conditions.

Objective

- To quantify the pollen-mediated gene flow from glyphosate-resistant to susceptible giant ragweed under field conditions

Materials and Methods

- **Field experiments:** South Central Agricultural Lab (46.59^0N, 116.14^0W), UNL; 2014 and 2015
- **Design:** A modified Nelder wheel design with a round center (10 m diameter; 80 sq m area) surrounded by pollen receptor area divided into eight directions (four cardinal directions i.e. N, S, E, and W; and four ordinal directions i.e. NE, NW, SE, and SW) (Jhala et al. 2011).
- Confirmed glyphosate-resistant giant ragweed plants were transplanted in the center as pollen source and known glyphosate-susceptible plants (pollen receptors) were transplanted in 6 m rows starting from 0.5 m to 35 m in cardinal directions and up to 50 m in ordinal directions (Figure 1).
- Data for flowering synchrony between source and receptor plants and hourly weather parameters were recorded throughout the duration of field experiments.
- Seeds were harvested separately for each distance in all the directions from the pollen receptor plants.
- **Screening:** The seedlings were grown in greenhouse and sprayed with 2× (1× = 1,260 g ha^{-1}) rate of glyphosate to determine outcrossing using glyphosate-resistance as a selective marker.
- **Statistical analysis:** The mean frequencies of gene flow were regressed over distance using exponential decay model in R software (R foundation for statistical computing, Austria)
- $P = ae^{-bd}$, where **P** is the predicted frequency of gene flow, **a** is the intercept, **b** is the slope of the curve, and **d** is the mean distance from the pollen source (m).
- Distances for 50 and 90% reduction in gene flow were calculated by using equations $O_{50} = \frac{\ln(0.5 \times a) - \ln(a)}{-b}$; $O_{90} = \frac{\ln(0.1 \times a) - \ln(a)}{-b}$, where a is intercept and b is slope (Jhala 2011).
- Flowering synchrony was determined as the number of days receptor and donor giant ragweed plants flowered together divided by total number of flowering days multiplied by 100 (Walsh et al. 2015).
- Effect of directions on gene flow was assessed by comparing the model parameters graphically and confirmed by ANOVA considering parameter values as response and direction as treatment variable (Figure 4).



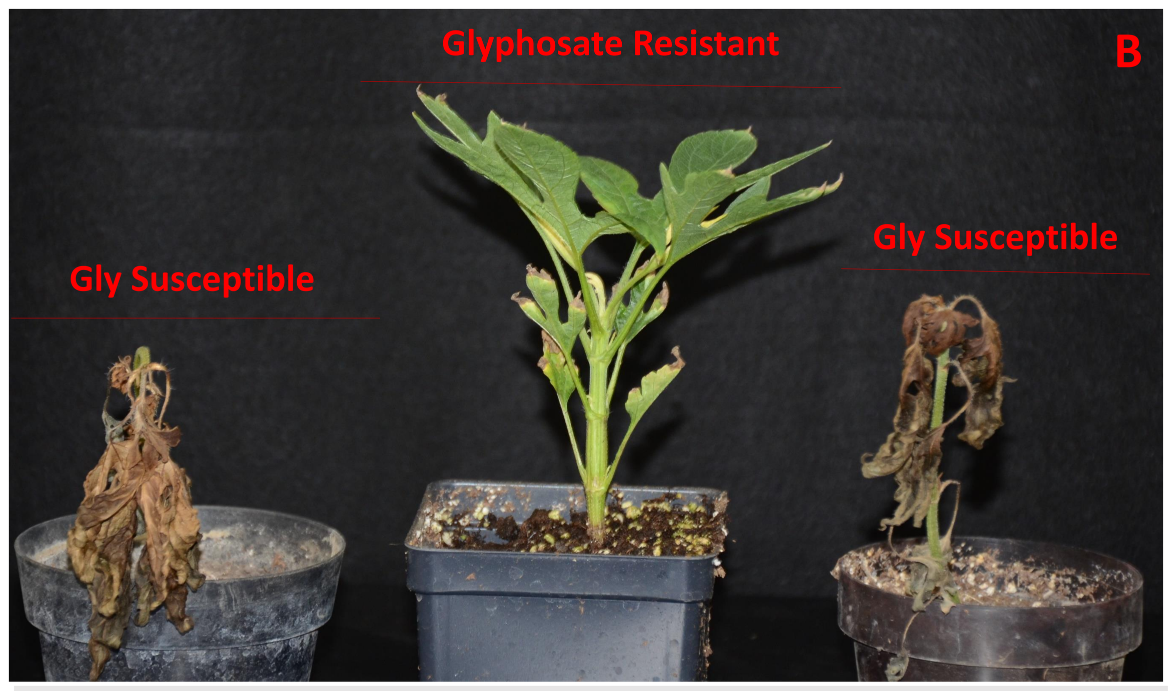


Figure 1. A). Aerial view of experimental site demonstrating pollen donor (center) and receptor plants of giant ragweed in four cardinal and ordinal directions; B). Resistant and susceptible giant ragweed plants from populations used as pollen source and receptors in this study 15 DAT with glyphosate at 2× (1× = 1,260 g ha^{-1}) rate

Results and Discussion

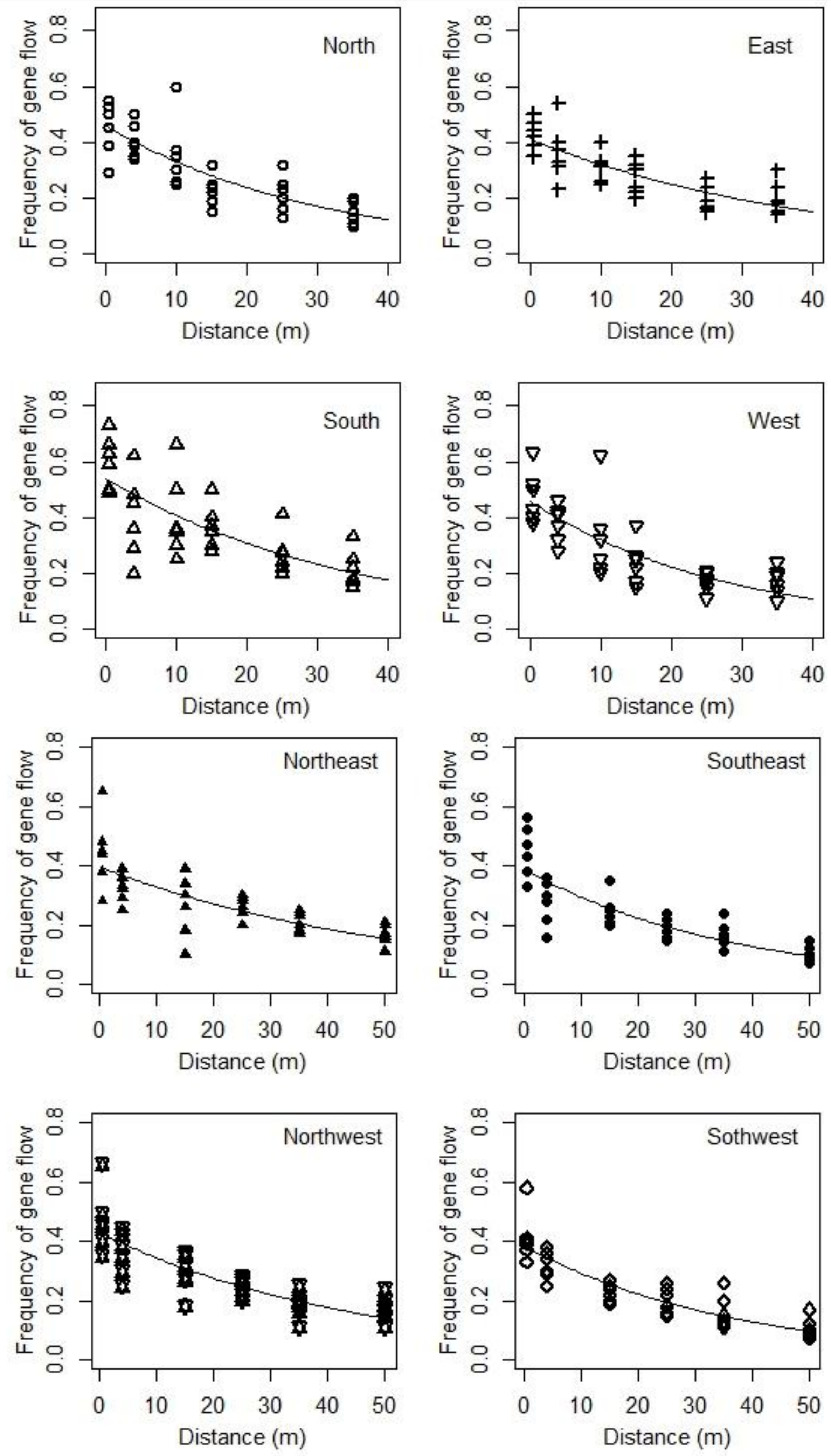


Figure 2. Pollen-mediated gene flow frequency over distances

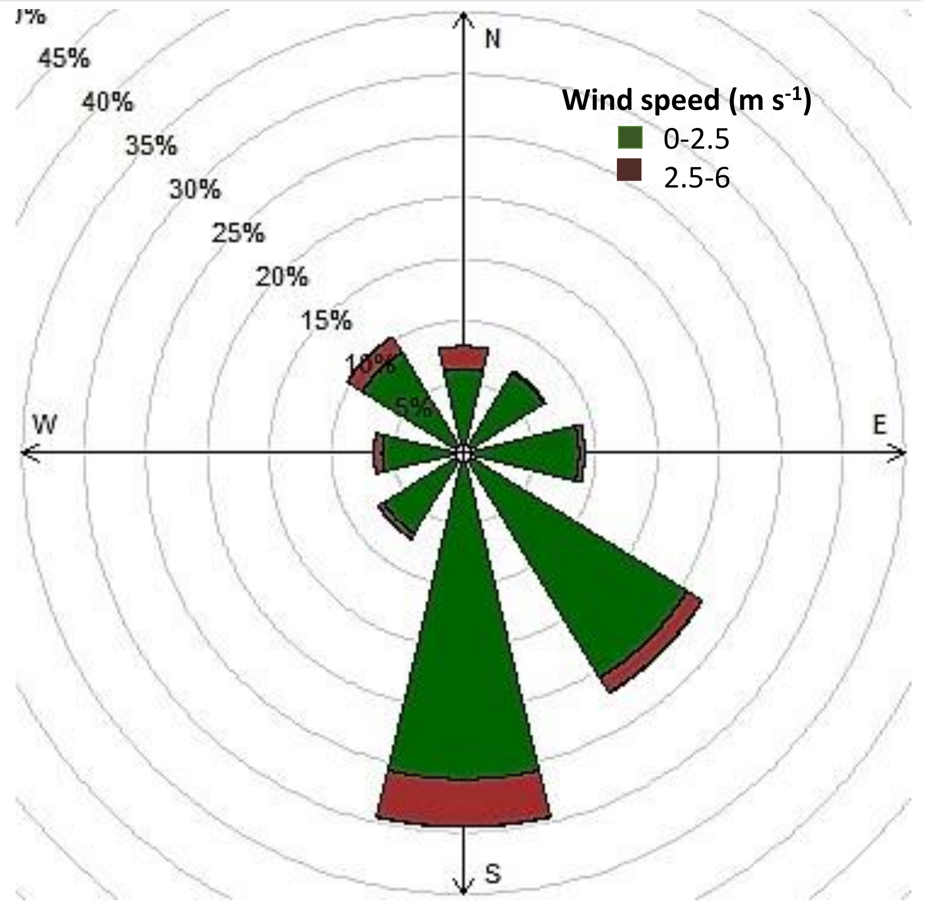


Figure 3. Frequency and distribution of wind speed and direction (blowing from) during anthesis

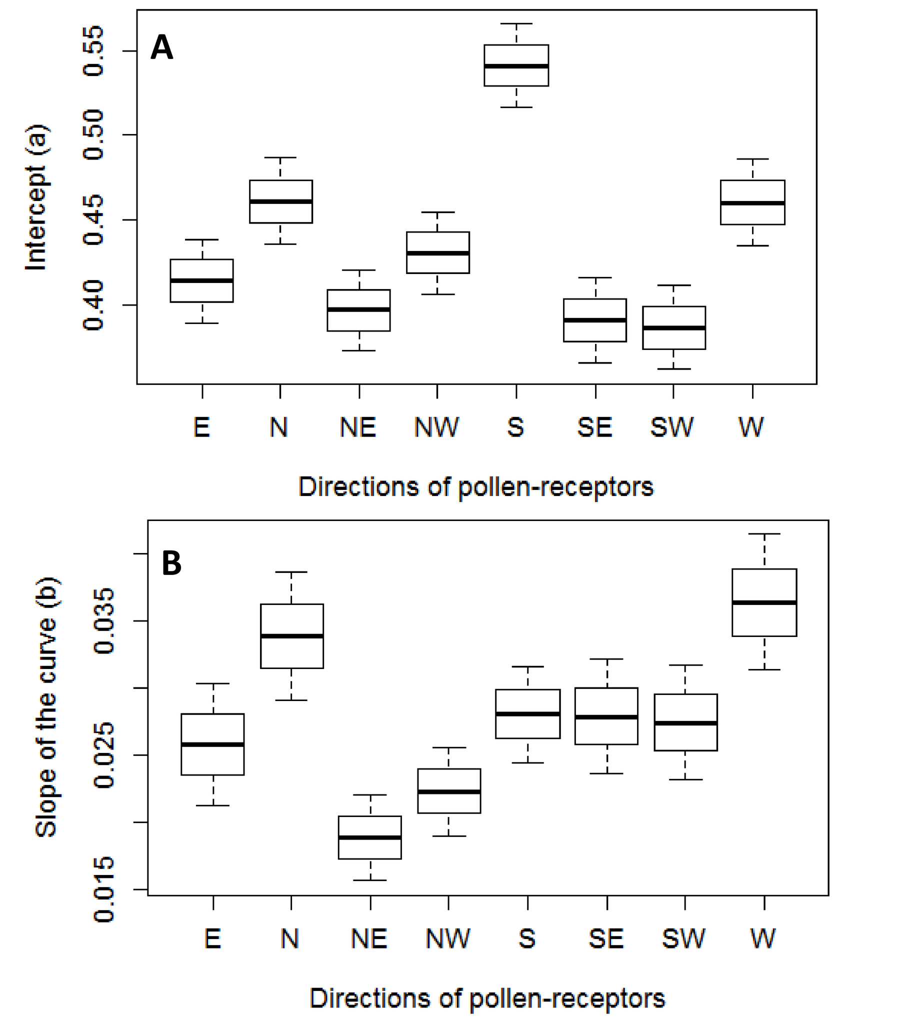


Figure 4. Parameters of exponential decay model ($P = ae^{-bd}$) over directions

- Flowering period lasted from the fourth week of July to end of September with >90% flowering synchrony between glyphosate-resistant pollen source and susceptible pollen receptor plants during both years of field experiment.
- Frequency of gene flow was 0.38 to 0.54 at 0.5 m and 0.1 to 0.17 at 50 m distance from the pollen source and varied with directions (Figure 2).
- Average pollen mediated gene flow decreased by 50% and 90% at 19 to 37 m and 63 to 122 m from the source, respectively.
- The model parameters varied between the directions indicating the effect of wind directions and speed on frequency of gene flow (Figure 4). Earlier studies reported major pollen dispersal within short distance with 31 and 5% crossing between ALS-resistant giant ragweed and susceptible common ragweed at 5 and 60 m respectively (Volenberg et al. 2005).

Conclusion

- Frequency of gene flow from glyphosate-resistant giant ragweed decreases exponentially with increasing distance from the pollen source.
- Frequency of gene flow varied between the directions suggesting influence of wind direction and speed; however, more information on pollen biology (pollen viability; pollen morphology) is needed to explain this effect.
- Gene flow on landscape scale is needed to evaluate the impact of vegetation and geographical barriers, population size, initial frequency of resistance allele and environmental factors including wind, humidity, temperature and precipitation.

Literature Cited

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