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|  | **pollen** | **seed** |
| **Source field** |  | Seed concentration and deposition, along with atmospheric data, were measured in a source field (180\*46 m) and its surrounding areas up to 1km downwind horizontally and up to 100m vertically. |
| **Source strength** | 0 to 140 grains/pant/second | 0 to 0.41 seeds/plant/second |
| **Pollen grains(total)** | 10.5\*1010(2.3 \* 106 per plant) | 158,876 (1.6 \* 105) seeds/plant for the life of the experiment |
| **The correlation between Source strength and meteorological data** | The release of horseweed pollen was not strongly correlated to meteorological data and may be mainly determined by horseweed physiology. | 1. Correlation analysis showed that the seed emission was mainly affected by horizontal wind speed. 2. Horizontal seed transport was mainly affected by horizontal wind speed and horizontal turbulence, while the major atmospheric parameter affecting vertical transport was vertical wind velocity. 3. This study investigates how horseweed seeds travel in the atmosphere. |
| **Deposition vs distance** | Normalized( by source data) pollen deposition with distance followed a negative-power exponential curve. | Normalized( by source data) seed deposition with distance followed a negative power exponential function. |
| **Max distance** | Normalized pollen deposition was 2.5% even at 480m downwind from the source edge. |  |
| **Reached height** | Horseweed pollen reached heights of 80 to 100 m, making long-distance transport possible. | Horseweed seeds were observed reaching heights of 80 to 100m, making long-distance transport possible. |
| **Correlation analysis** | 1. Correlation analysis showed that close to or inside the source field (<=3m) vertical transport was related to vertical wind speed, while horizontal pollen transport was related to horizontal wind speed. 2. High relative humidity prevented pollen transport at greater heights(3-100m) and longer distances(0-1000m) from the source. |  |
| **value** | 1.This study can contribute to the understanding of how herbicide-resistance weeds or invasive plants affect ecology through wind-mediated pollination and invasion. | 1.This study investigates how horseweed seeds travel in the atmosphere.  2. The experimental data can also help in developing and evaluating seed/particle dispersion models. |

**Introduction**

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|  | **Pollen** | **Seed** |
| **Biological traits** | 1. 1.Usually, the pollen longevity is about 2h(von Hout et al. 2008). 2. 2.Pollen production during flowering can vary by orders of magnitude from day-to-day, and the total volume of pollen grains released in a season can vary significantly year-to-year(Subiza et al. 1992; Emberlin et al. 1993). | 1. Horseweed is mainly self-fertilized; glyphosate-resistant(GR) horseweed can pollinate glyphosate-susceptible(GS) horseweed (4% outcrossing rate reported by Smisek 1995 and Henry et al.2008). |
| **Reached height and distance** |  | 1. The seeds can be lifted above 68-120m altitude(Dauer et al.2009). 2. The seeds will potentially be carried for hours before descending (Dauer et al. 2009) and therefore would be transferred long distances. |
| **significance** | 1.An increased understanding of the pollen and seed dispersion process would benefit the selection of strategies to control the spread of horseweed, especially resistant biotypes, across agricultural fields. | 1.Strategies to control the spread of horseweed, especially resistant biotypes, across agricultural fields or natural lands require an increased understanding of the seed dispersion process.  2. Understanding these factors that influence dispersal distance is essential in policy making. |
| **Status of research** | 1. Horseweed gene flow studies have been largely focused on seed spread (Dauer et al. 2006,2007,2009; Shields et al.2006) instead of pollen transport, pollination, and outcrossing. 2. However, there is little information available about its pollen production, atmospheric dispersion, and depositon. 3. Pollen travel proximate to its source has been studied for many plant species to address pollen allergies(Holmes and Bassett 1963; Stark et al.1997; Aboulaich et al.2013) or gene flow in agricultural field crops( Llewellyn and Fitt 1996; Jarosz et al.2003,2005; von Hout et al.2008). 4. But studies of horseweed pollen emission and dispersion(either close to or far from the source) are lacking. | 1. There are no experimental studies on dynamic seed release rate and dispersion and deposition with distance. 2. There were experimental studies on seed vertical dispersion in the air(Dauer et al.2009;Shields et al.2006). 3. In particular, little information is available on the relationship of seed release rate and horizontal dispersion and deposition with atmospheric conditions (wind speed, direction, wind variability, and atmospheric stability). |
| **Difficulties of research** | 1. Assessing and predicting pollen emissions can be challenging because the mechanisms of pollen release are sensitive to factors relative to plant biology, meteorological conditions, and local terrain (Menut et al.2014). | 1. |
| **Objectives of this study** | 1. measure atmospheric dynamic ( on the order of an hour) horseweed pollen emission, dispersion, and deposition in the vertical direction(up to 100m) and in the horizontal direction(up to 1000m); 2. quantify the correlation between horseweed pollen emission, dispersion, and deposition and atmospheric parameters. | 1.Measure the atmospheric dynamic (on the order of an hour) and horseweed seed emission, dispersion, and deposition in the vertical direction (up to 100m) and in the horizontal direction (up to 1000m);  2. quantify the correlation between horseweed seed emission, and deposition and atmospheric parameters. |
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**Materials and Methods**

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|  | **Pollen** | **Seed** |
| **Biological outlook** | 1. 1.Horseweed pollen grains are prolate spheroid-shaped and have a spiked,rough surface. The polar axis(P) of horseweed pollen has an average axis length of 22 um, and the equatorial diameter(E) of the pollen grains has an average size of 16um. | 1. small achenes (1.6-6.4 mm long), with a pappus of tan to white bristles |
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Result

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|  | **Pollen** | **Seed** |
| **Concentration variation** | 1. 1. The concentration variation with height followed a negative power function. The concentration was maximized at the lowest height and decreased rapidly with height (Fig. 5). The rapid varia-tion occurred from ground level to 5 m. At 10- to 100-m heights, the concentration decreased slowly and the variation was small.   As shown in Fig. 4 and 5, seeds were found at heights of 80 to 100 m (0-10% of source concentration), which was about 0 to 0.05 seeds/m3. Therefore, seeds can be dispersed to a high altitude and potentially to a far distance.  At 20 to 40 m downwind and at lower heights (<10 m), seed concentration was in the range of 2-90% (0.02 to 0.6 seeds/m3) of the source concentration (Fig. 4). At a further distance of 40-70 m at low heights (<10 m), 2 to 20% (0.02 to 0.3 seeds/m3) of seed concentration re-mained. At 70-150 m in the downwind direction, many concentrations in the air (all heights) were on the order of 0 to 5% of the concentration at the source (about 0 to 0.05 seeds/m3). | 1. small achenes (1.6-6.4 mm long), with a pappus of tan to white bristles |
| Emission rate | 0-140 grains/plant/sec |  |
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