DEW FORMATION AND STEM FLOW ON COMMON RAGWEED (*AMBROSIA ARTEMISIIFOLIA*)[1]

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Abstract. Common ragweed (*Ambrosia artemisiifolia*) was found to possess an adaptation enabling the collection of dew and rainfall through stem flow. Stem wells were used to quantitatively determine the incidence and extent of dew collection by this mechanism. Stem flow averaged 2.85 ml of dew/plant · night during the study, which covered the latter portion of the ragweed growing season. Factors influencing dew collection included plant size, stage of phenological development, microhabitats, and the duration of dew exposure. The mechanism may play a vital ecological role in old field plant relationships.

Introduction

Both fog and dew are considered potentially important factors in the distribution and water economy of certain plant species (Went 1955). Extensive precipitation from fog droplets in maritime regions (Vogelmann et al. 1968, Oberlander 1956) has been linked with the distributional pattern of spruce-fir forests near eastern maritime areas (Davis 1966). Fog precipitation arises by the condensing of water droplets on plant foliage with resultant flow along branches and down stem surfaces. This passive flow has been called fog drip as well as horizontal precipitation (Kittredge 1948).

The role of dew as a water supplement to plants has also been widely studied (Stone 1957*a*, 1963, Duvdevani 1964). The effects of dew are believed to be quite varied, ranging from no effect to prolonging life in pine and other seedlings under simulated drought stress conditions (Stone 1957*b*). Previous studies on the importance of dew have concerned either direct foliar absorption of dew or its influence on cuticular transpiration (Slatyer 1960). Little evidence has been presented supporting the existence of a dew drip mechanism analogous to that present under heavy fog conditions. Waisel (1960), however, mentioned that *Tamarix aphylla* could precipitate moisture at levels below saturation or fog formation. Duvdevani (1964) indicated that high dew levels on certain plants in Israel leads to droplet coalescence and then run-off. Considering the relatively low efficiency of water absorption through most leaf surfaces (Vaadia and Waisel 1963, Slatyer 1960), the presence of an adaptation for dew collection could represent an important factor in the competitive relationships among plant species. Gindel (1965) has shown the importance of experimental dew collectors on sapling survival in desert areas of Israel.

In 1967 and 1968 field observations we made on common ragweed (*Ambrosia artemisiifolia*) in New Jersey suggested the presence of an adaptation enabling the collection of dew and rainfall. During this period we often noted that ragweed foliage dried much more rapidly than other old-field plant species both in the morning after dew accumulation and following rainfall. The presence of a unique adaptation for dew collection was further substantiated during radionuclide tracer studies on the food web of this dominant old-field producer (Shure 1973). "Stem wells" (Wiegert and Lindeborg 1964) placed around the base of ragweed stems were full of water each morning without rainfall having occurred. Similar wells placed on other old-field plant dominants including *Raphanus raphanistrum* and *Chenopodium album* were always empty. These observations indicated a definite adaptation in ragweed enabling the collection of nightly dew condensate.

The present study was conducted to gain quantitative information on dew collection as a moisture supplement to ragweed. Data were obtained on the extent of dew collection by ragweed plants of different size, in different areas, and at different stages of phenological development.

Methods

The research was conducted in first-year old fields adjacent to Hutcheson Memorial Forest near East Millstone, New Jersey. The fields were plowed during April 1969 and then abandoned. The pattern of initial succession in these fields has been summarized elsewhere (Bard 1952, Shure 1971, 1973).

Stem collection experiments were conducted at two different times during the 1969 growing season. On August 3, 1969, we randomly selected 18 ragweed plants within each of two field sites to study dew precipitation through stem flow. Dew interception

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TABLE 1. The incidence and amount of dew collection by ragweed in different experiments and for different degrees of dew exposure. Data reflect number of plants collecting dew each evening (No.) and $\bar{x}$ amount collected by all plants in each area. Plant biomass and height by cover measurements are expressed as $\bar{x} \pm 1$ SE

	Sample area	No. plants	$\bar{x}$ Plant biomass (Dry wt. g)	$\bar{x}$ Plant Ht x cover (Cm²)	Incidence and amount (ml) of dew collection														
					8/3 $\bar{x}$	No.	8/7 $\bar{x}$	No.	8/8 $\bar{x}$	No.	8/9 $\bar{x}$	No.	8/11 $\bar{x}$	No.	8/12 $\bar{x}$	No.	8/13 $\bar{x}$	No.	$\bar{x}$
Exp. I	1	16	10.3±0.77	2108±131	0.83	13	2.81	16	1.38	15	4.24	16	0.40	10	2.80	16	1.08	16	1.93
	2	16	8.9±0.38	2180±133	0.68	13	3.27	14	1.86	14	8.78	16	0.38	12	4.89	15	1.68	14	3.08
			Hr below dewpoint		2		2		2		8		0		1		1		
					8/24		8/23		8/25		8/27		8/28		8/29		8/30		
Exp. II	3	15	24.4±2.85	4991±257	3.22	15	0.95	12	1.27	13	0.00	0	0.38	8	0.59	10	0.47	9	0.98
	4	16	30.4±3.15	8291±542	12.18	16	6.84	15	7.32	14	0.00	0	4.11	14	3.90	14	3.48	14	5.40
			Hr below dewpoint		7		6		5		0		8		10		5		

data were obtained from these 36 plants until August 13. On August 19 we randomly selected another 18 plants from two separate areas to determine dew collection during the later period of ragweed development. Data were collected in these areas until August 30.

We estimated ragweed collection of dew by fastening stem wells to the base of each plant below the point of branching. The wells were constructed from plastic tape and had capacities of approximately 7, 12, or 20 ml, depending on plant size and stem diameter. These wells intercepted all dew that accumulated on ragweed foliage and subsequently flowed down the stem. Control wells were placed on wooden dowels located adjacent to the field sites to check for evening rainfall. We recorded dew collection only if no rainfall had occurred.

Plants with wells that leaked during the experiment were omitted from the computations. This resulted in the use of only 32 and 31 of the original 36 plants selected for each of the two experiments. Dew accumulation was measured each morning before 0900 hr to minimize water loss by evaporation. The water removed from each well was added to the soil at the plant base to minimize disturbance of the natural mechanism.

The height and cover of each plant was measured at the end of each experiment. We measured plant cover in the field using the line intercept method (Buell and Cantlon 1950). We then harvested all plants and returned them to the laboratory for biomass determinations. The total wet and dry weight of each plant was determined as well as the dry weight of leaf and stem components.

Temperature and relative humidity were measured continuously during August with a Friez hygrothermograph (Model 594). These measurements were used to determine the temperature of the dew point each evening (Torok 1935) and the number of hours per night the temperature remained below dew point.

RESULTS

Dew collection by stem flow provided a consistent source of water to ragweed during the summer growing season (Table 1). Stem flow occurred on 13 of the 14 nights during August when data were recorded. Each of the 63 experimental plants exhibited dew collection at least once, with most plants collecting dew each evening.

The extent of dew collection by ragweed was quite varied over the study. Stem flow ranged from less than 1 ml per plant on several nights to a high of 12.18 ml per plant in area 4 on August 22. The average amount of dew collection by stem flow was 2.51 ml/plant · night in early August and 3.19 ml/plant · night in late August.

Several factors including plant size, phenology, hours below dew point, and microenvironmental variation apparently interacted in determining the extent of dew collection by ragweed. In early August the daily change in dew collection followed a similar pattern in both study areas. Ragweed plants, which were growing rapidly at this period, were similar in size in both areas. The relative fluctuations in dew collection during early August were somewhat correlated with the number of hours below dew point.

In late August the dew collection by ragweed was quite different in the two sample areas (Table 1). Little dew was collected in area 3 despite the larger plant size and more dew exposure (hr/night) than in early August. Dew collection by ragweed was much higher in area 4, where plant size and relative cover was greatest. The wide variation in dew collection between areas 3 and 4 was believed partly due to microenvironmental differences in the two areas. The fact that total plant size and cover were greater in area 4 may have strongly influenced the relative humidity within the vegetation and therefore the extent of dew collection by ragweed.

The phenological stage of development of ragweed may have also been involved in the differences that developed. Both area 3 and 4 showed a decline in dew collection during experiment II, when ragweed was rapidly completing its annual cycle. This drop occurred despite a high dew exposure (hrs/night) at the end of the experiment. A morphological or physiological alteration of the stem flow mechanism near the end of ragweed's annual cycle may therefore have produced the drop in total dew collection during late August. This alteration of the mechanism may have occurred earlier in area 3 because of the environmental differences.

Discussion

Dew collection through stem flow provides a consistent source of water to the root system of ragweed. Factors believed influencing the extent of this adaptation include plant size, stage of phenological development, microhabitats, and the duration of dew exposure. The specific mechanism enabling this adaptation is still unknown, however. The morphology of ragweed foliage may be such that condensation naturally collects and funnels down the stem largely through gravity flow. A morphological change causing the funneling of dew may result instead from changes in turgor pressure within the leaves at the onset of dew or rainfall. Further experimentation is needed to determine the specific morphological or physiological basis of this mechanism.

This adaptation of ragweed for the collection of dew and rainfall may play an important role in early plant succession within old-field ecosystems. Ragweed is the dominant producer during the initial year of succession on old fields in the northeastern United States (Bard 1952). Successional studies during 1968 (Shure 1971) indicated ragweed reached a density of 18.4 plants/m^2 in the same old fields used in the current study. Ragweed production appeared similar during the 1968 and 1969 growing seasons. Assuming similar plant size and density both summers, the total dew collection (D.C.) by ragweed would equal approximately

$$\text{D.C.} = 2.85 \text{ ml/plant} \cdot \text{night} \times 21 \text{ rain-free nights} \times 18.4 \text{ plants/m}^2 \text{ in August}$$

$$\text{D.C.} = 1101 \text{ ml/month} \cdot \text{m}^2$$

This estimate illustrates the large amount of water made available to the root system of ragweed during the growing season. Dew collection plus the additional stem flow during rainfall may therefore provide a competitive advantage for ragweed which enhances its dominant status as an invading weed species. This adaptation would be especially critical during dry periods when soil moisture becomes a serious limiting factor.

Additional ecological factors may be associated with the dew collection mechanism. Dew condensation on plant foliage provides an aqueous medium for leaching of foliar metabolites present on or within leaf or branch surfaces (Tukey and Mecklenburg 1964). These metabolites may include many essential chemical elements (Tukey 1966) which become available to the root system through stem flow and are recycled for plant usage. Allelopathic substances can also be transmitted through similar mechanisms (del Moral and Muller 1969). Hence, dew precipitation, while directly increasing available moisture to ragweed, may also indirectly benefit the species through the recycling of important chemical elements or by reduction of interspecific competition through allelopathic responses. This adaptation of ragweed may thus play a vital role in governing the density, diversity, and distribution of plant species within old-field ecosystems. The presence of similar adaptations should be investigated in other plant species.

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