

Yellow Starthistle: Biology and Life History

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Introduction and Spread

The center of origin of yellow starthistle (*Centaurea solstitialis* L.) is believed to be Eurasia, where it is native to Balkan-Asia Minor, the Middle East and south-central Europe (Maddox 1981). It has been speculated that the introduction of yellow starthistle into California occurred on multiple occasions, but early introductions were probably always associated with seed contamination in alfalfa (Maddox et al. 1985). The first reported collection of yellow starthistle in North America was made in Oakland in 1869. Its subsequent spread was slow until the mid-1900's. By the late 1950's, the weed infested over 1 million acres of California. Infestations reached nearly 8 million acres in California by 1985 (Maddox and Mayfield 1985), and perhaps 10 - 12 million acres by 1995.

Yellow starthistle can be found in 23 of the 48 contiguous states, extending as far east as New York. It has also extended into Canada from British Columbia to Ontario. Although it is widespread in North America, the primary infestations occur in the western United States. The largest infestations are found in California, where it was reported to exist in 52 of the 58 counties (Maddox et al. 1985).

Biology

Several factors contributed to the success of yellow starthistle in California, particularly characteristics associated with germination, growth and reproduction.

Germination

Two types of seed are present in yellow starthistle seedheads. The outer ring of seeds are dark and lack a pappus. The majority of seed, however, are brown with a bristly pappus ring at the apex. Both seed types will germinate over an extended time period in California, beginning with the first fall rains and ending after the last seasonal rainfall in late spring or early summer. The germination rate of the pappus-bearing seed is higher in late fall and winter, whereas the rate of the nonpappus-bearing seed higher in spring (DiTomaso, unpublished).

Provided that adequate moisture is available, germination can occur with 24 hours of imbibition (Sheley et al. 1993). Yellow starthistle seeds are capable of germinating over a wide range of temperatures, but appear to be dependent upon light. Germination in the absence of shading was 85%, but only 1% under 4 inches of grass litter and 11% under 4 inches of yellow starthistle litter (Prather 1994). In exposed areas, high germination can result in extremely dense seedling populations. In these areas, seedling survival is usually very low (<3%) (Prather 1994). However, the density of surviving plants are sufficient to reinfest an area year after year.

The average longevity of pappus-bearing and nonpappus-bearing seeds in the soil was reported by Callihan et al. (1993) to be 10 and 6 years, respectively, in yellow starthistle from Idaho. After 10 years in the soil, they predicted the viability of remaining seed was about 2%. In California, however, the seedbank of a Placer County population of yellow starthistle was shown to be depleted by over 80% after a single year, 94% after two years, and between 96 and 99% after 3 years, provided further seed recruitment was prevented (Joley et al. 1992). In a burning study conducted at Sugarloaf Ridge State Park, Sonoma County, yellow starthistle seedbank was reduced by over 99% after three years of prescribed burning (Hastings and DiTomaso 1996). The difference between the Idaho and California populations may be due to genetic variability or environmental conditions between the sites. In California, however, it seems possible to deplete the seedbank of yellow starthistle within a few years, as long as new seed recruitment does not occur from neighboring populations or plants escaping control.

Growth

Roots - Following germination, the growth strategy of yellow starthistle is to initially allocate resources to root growth, secondarily to leaf expansion, and finally to stem development and flower production (Roche et al. 1994). Root growth during the winter is rapid and can extend well beyond 3 feet in depth (Figure 1). During this same time period, rosettes are expanding slowly. The rate of root growth during March has been reported to be as rapid as 1 inch per day (Roche et al. 1994; Sheley et al. 1993; Sheley and Larson 1994a). Rapid germination and deep root growth in yellow starthistle allows plants to avoid late season competition with other annual species and survive into late summer, long after seasonal rainfall has ended and annual grasses have senesced. By extending the period of resource availability, competition is reduced at the reproductive stage. This can greatly benefit the plant by insuring ample seed production (Sheley et al. 1993).

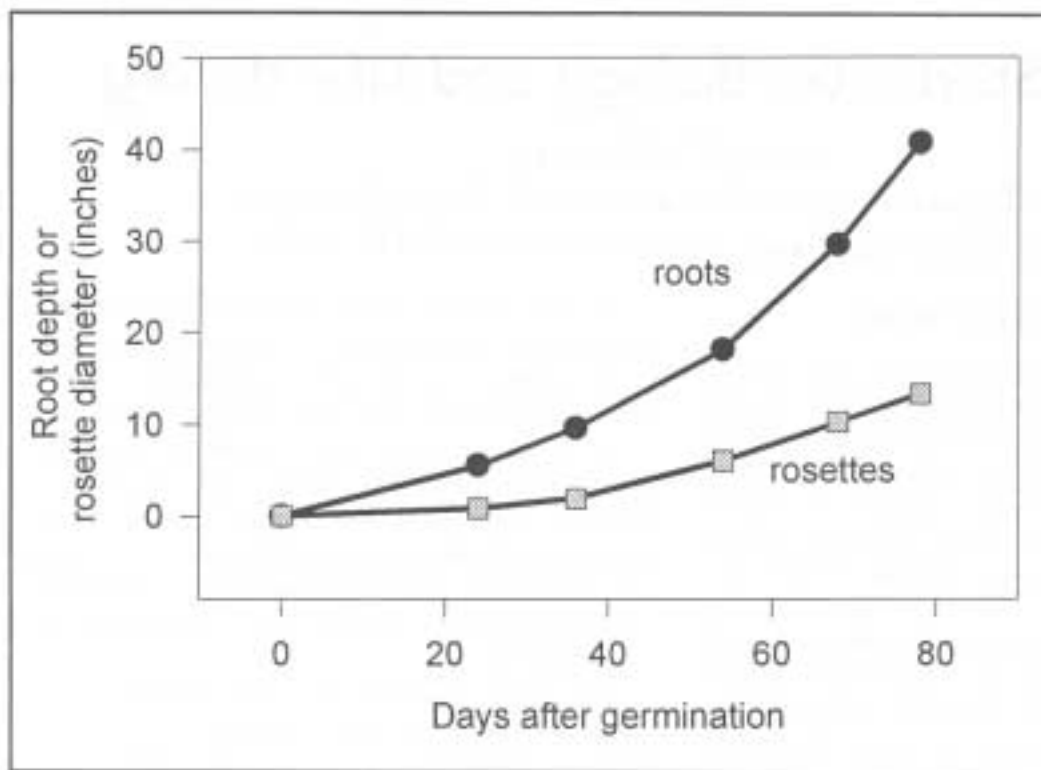


Figure 1. Root and rosette growth in yellow starthistle seedlings planted on January 19, 1996.

Shoots - Rosettes continue to develop throughout the early spring. In grasslands where rosettes are exposed to low light, the leaves are larger and more erect, whereas developing leaves are flatter and more compacted in full sunlight (Roche et al. 1994). Dense yellow starthistle seedling cover can significantly suppress the establishment of annual grasses and forbs. In these stands, competition for light is intense and yellow starthistle seedlings vigorously compete with each other, accounting for the low rate of seedling survival.

In the Central Valley and foothills of California, bolting typically occurs in early summer and by midsummer spines appear on developing seedheads. At the more mature stages of development, the pubescence and waxy grayish coating on the foliage of yellow starthistle reflect a considerable amount of light. This reduces the heat load and the transpiration demand during the hot and dry summer months (Prather 1994). In addition, the winged stems add surface area and also act to dissipate heat just as a radiator does. These characteristics, as well as a deep root system, allow yellow starthistle to thrive under full sunlight in hot and dry conditions. Moreover, the presence of spines on the bracts surrounding the seedhead provides protection against herbivory. This is particularly important during the vulnerable flowering and seed development stages.

Reproduction

Yellow starthistle typically begins flowering in late May and continues through September. There are very low levels of self-fertilization in yellow starthistle (Maddox et al. 1996). Thus, a significant amount of cross-fertilization insures a high degree of genetic variability within populations.

Honeybees play an important role in the pollination of yellow starthistle, and have been reported to account for 50% of seed set (Maddox et al. 1996). Bumblebees are the second most important floral visitor to starthistle flowers, but several other insects also contribute to fertilization of the ovules (Harrod and Taylor 1995).

The time period from flower initiation to the development of mature viable seed is only 9 days (Figure 2). Thus, any late season control strategy such as mowing, herbicides, burning, or tillage must be performed earlier than 9 days after flowering initiation to prevent seed production.

Nonpappus-bearing seed became viable before most pappus-bearing seed (Maddox et al. 1996). Maddox (1981) reported the average number of seeds per head to be between 38 and 43, whereas we found an average of 74 seeds per seedhead in a population in Davis, California (DiTomaso, unpublished data). The ratio of pappus-bearing to nonpappus-bearing seeds appears to be quite variable, ranging from 3:1 to nearly 9:1 (Maddox 1981; Callihan et al. 1993).

Total seed production can also vary widely, depending upon the level of infestation, soil depth, and moisture available. In several infested areas, Sheley and Larson (1994b) measured production at between 23 and 94 million seed per acre. Despite this range in seed production, self-thinning resulted in the adult population remaining constant at 20 plants per square foot (870,000 per acre).

The pappus-bearing seed are usually dispersed soon after the flowerheads senesce and drop their petals. However, nonpappus-bearing seeds can be retained in the seed head for a considerable period of time, extending into the winter (Callihan et al. 1993). Wind does not contribute to long distance dispersal of pappus-bearing yellow starthistle seed. Roche (1992) reported 92% of the seed within 2 feet of the parent plant, and no seed as far as 32 feet away. By comparison, birds such as pheasants, quail, house finches, and goldfinches feed heavily on yellow starthistle seeds and are capable of long distance dispersal. Human activity, including vehicles, contaminated seed, road maintenance, and moving livestock, can also contribute to rapid and long distance spread of the seed (Roche 1992).

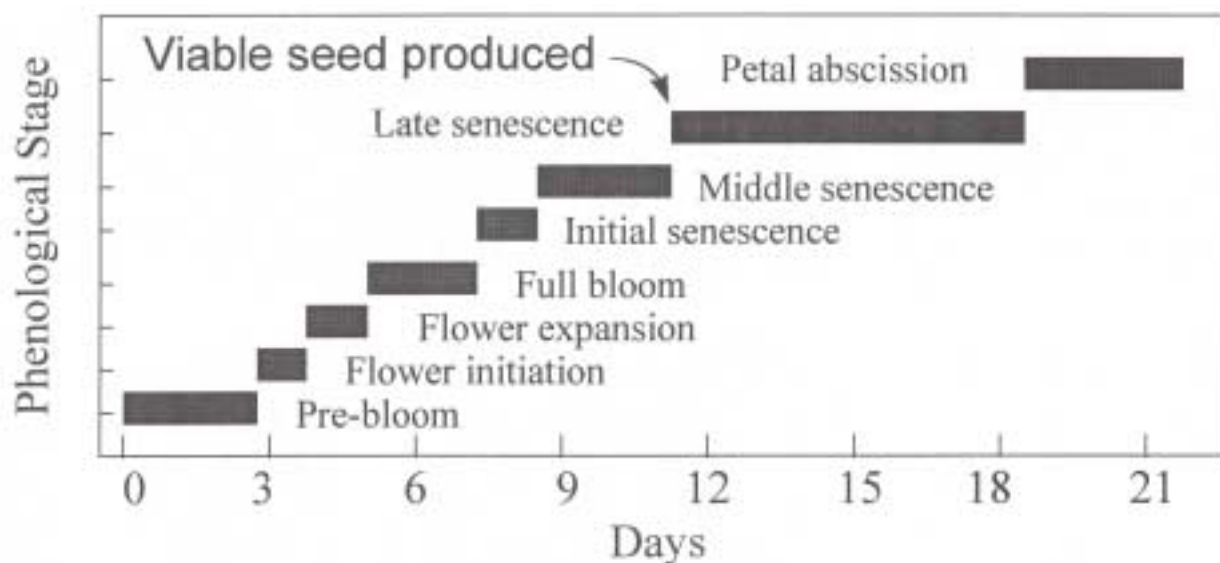


Figure 2. Phenological development of yellow starthistle flowers from pre-bloom spiny stage to petal abscission. Seed viability occurred at late senescence stage.

Ecology

Habitat

Yellow starthistle can survive on deep, well-drained soil, or shallow, rocky soils at an annual precipitation between 10 and 40 inches (Maddox et al. 1985; Lanini et al. 1996). Deeper soils favor increased growth of yellow starthistle (Roche et al. 1994). Although infestations have been reported to occur from sea level to slightly over

5,000 feet elevation, populations have recently been reported at high as 7,000 feet (DiTomaso, personal observation).

Competition

Yellow starthistle is not competitive under shaded conditions (Roche et al. 1994). Rosettes are particularly susceptible to shading and do not compete well in areas dominated by shrubs, trees or by taller perennial forbs and grasses. For this reason, infestations are nearly always restricted to open grasslands or disturbed sites.

Roots can extend more than 3 feet deep into the soil profile by mid-spring. At the same time, rosettes may still be relatively small (Lanini et al. 1996). Since the root system of most annual species is comparatively shallow, there is little competitive interaction for moisture between yellow starthistle and annual grasses during late fall and early summer. In contrast, the use of soil moisture by yellow starthistle was shown to be similar to that of perennial grasses (Borman et al. 1992). Like yellow starthistle, perennial grasses have an extended growing season. Thus, they are likely to compete more for water with yellow starthistle than annual species.

References

- Borman, M.M., D.E. Johnson and W.C. Krueaer. 1992. Soil moisture extraction by vegetation in a Mediterranean/maritime climatic regime. *Agronomy Journal*. 84:897-904.
- Callihan, R.H., T.S. Prather and F.E. Northam. 1993. Longevity of yellow starthistle (*Centaurea solstitialis*) achenes in soil. *Weed Technology*. 7:33-35.
- Harrod, R.J. and R.J. Taylor. 1995. Reproductive biology of four knapweeds. *Knapweed*. 9(2):1-2.
- Hastings, M. and J.M. DiTomaso. 1996. The use of fire for yellow starthistle (*Centaurea solstitialis*) management and the restoration of native grasslands at Sugarloaf Ridge State Park. *CalEPPC NEWS*. 4(1):4-6.
- Joley, D.B., D.M. Maddox, D.M. Supkoff and A. Mayfield. 1992. Dynamics of yellow starthistle (*Centaurea solstitialis*) achenes in field and laboratory. *Weed Science* 40:190-194.
- Lanini, W.T., C.D. Thomsen, T.S. Prather, C.E. Turner, J.M. DiTomaso, M.J. Smith, C.L. Elmore, M.P. Vayssieres and W.A. Williams. 1995. Yellow starthistle. *Pest Notes*. 3:1-4.
- Maddox, D.M. 1981. Introduction, phenology, and density of yellow starthistle in coastal, intercoastal, and Central Valley situations in California. *USDA-ARS. ARR-W-20*. Pages 1-33.
- Maddox, D.M., D.B. Joley, D.M. Supkoff and A. Mayfield. 1996. Pollination biology of yellow starthistle (*Centaurea solstitialis*) in California. *Canadian Journal of Botany*. 74:262-267.
- Maddox, D.M. and A. Mayfield. 1985. Yellow starthistle infestations are on the increase. *California Agriculture*. 39(6):10-12.
- Maddox, D.M. A. Mayfield, and N.H. Poritz. 1985. Distribution of yellow starthistle (*Centaurea solstitialis*) and Russian knapweed (*Centaurea repens*). *Weed Science*. 33:315-327.
- Prather, T.S. 1994. Biology of yellow starthistle. *Proceedings of the California Weed Science Conference*. 46:219-223.
- Roche, B.F., Jr. 1992. Achene dispersal in yellow starthistle (*Centaurea solstitialis* L.). *Northwest Science*. 66:62-65.
- Roche, B.F., Jr., C.T. Roche and R.C. Chapman. 1994. Impacts of grassland habitat on yellow starthistle (*Centaurea solstitialis* L.) invasion. *Northwest Science*. 68:86-96.
- Sheley, R.L. and L.L. Larson. 1994a. Comparative - growth and interference between cheatgrass and yellow starthistle seedlings. *Journal of Range Management*. 47:470-474.
- Sheley, R.L. and L.L. Larson. 1994b. Observation: comparative life-history of cheatgrass and yellow starthistle. *Journal of Range Management*. 47:450-456.
- Sheley, R.L., L.L. Larson and D.E. Johnson. 1993. Germination and root dynamics of range weeds and forage species. *Weed Technology*. 7:234-237.