BREEDING ALFALFA FOR CALIFORNIA RANGELANDS

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ABSTRACT

Extensive rangelands lack irrigation infrastructure, making dryland agriculture entirely reliant on rainfall. Alfalfa production on California rangelands is challenging due to the limited water availability from late spring through early autumn and the unpredictability of precipitation patterns during the rest of the year. Currently available rangeland-adapted alfalfa varieties are very fall dormant, which restricts their growth during fall, winter, and early spring, causing them to have limited productivity. Since California's Mediterranean climate delivers most of its annual rainfall in winter, breeding alfalfa with reduced dormancy offers an opportunity to better align growth with water availability in regions that do not experience severe winter conditions. Our selections prioritize low fall dormancy, varied root systems, and resilience under limited water availability. We are performing on-farm variety trials and evaluating new germplasm to select plants for improved productivity while maintaining persistence of alfalfa in extensive grazing systems.

Key Words: Alfalfa, rangelands, dryland agriculture, Mediterranean climate, plant breeding

INTRODUCTION

Rangelands are a vital part of California's agriculture, making up 57 million acres, of which approximately 34.1 million acres are actively grazed (CDFF, 2010). However, productivity on these rangelands is often limited by factors like poor soil fertility and inconsistent water availability. One way to improve productivity is by incorporating legumes, like alfalfa, into these grazing systems. Alfalfa provides high-quality forage and contributes nitrogen to the soil through symbiotic nitrogen fixation, reducing the need for synthetic fertilizers (Popp et al., 2000). Alfalfa also offers additional environmental benefits on rangelands, such as reducing erosion, increasing soil organic matter, and supporting carbon sequestration (Mortensen et al., 2004). These benefits can simultaneously enhance both the sustainability and productivity of rangelands.

Alfalfa has a large natural variation in fall dormancy, the amount of regrowth that occurs in fall as temperatures decrease and the photoperiod shortens. Dormant alfalfa varieties are often adapted to colder climates and produce little growth in fall to conserve energy for winter survival. Non-dormant alfalfa varieties, which are suited to hotter, drier regions, have the ability to grow year-round if conditions are favorable, but they are more susceptible to death or damage during harsh winters. Due to these tradeoffs, alfalfa growers tend to choose varieties based on maximizing yield while still ensuring adequate winter survival. In areas with a mild winter, like much of California, other than the north and higher mountain elevations, growers who choose

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dormant cultivars will see significant yield penalties from fall through early spring compared to those with nondormant cultivars. Previous breeding efforts have successfully selected plants from non-dormant cultivars that can survive winter and improve yield (Weishaar et al., 2005; Smith and Bouton, 1993).

Planting date in California rangelands is limited because of the need for irrigation post-planting for stand establishment. In California, this means that alfalfa seeds must be drilled in the fall since winter is the only predictable season with precipitation, but fall dormant cultivars grow slowly over winter, jeopardizing successful establishment. Nondormant cultivars not only provide more yield over time but are also quicker to establish and able to outcompete native or invasive grasses when planted in the fall.

Hay-type alfalfa varieties are mainly developed using purple flowered *M. sativa* subspecies *sativa* germplasm, while rangeland varieties typically have yellow-flowered *falcata* parentage due to its superior tolerance to grazing, drought, and harsh winters (Boe et al. 2020, Mortenson et al., 2004). Falcata alfalfa is a valuable tool in breeding for persistence, as it has low-set crowns that reduce hoof damage during grazing, and some falcatas can spread underground through extensive fibrous root systems, which promotes persistence. Unlike typical alfalfa, which produces buds branching off the crown and occasionally rhizomes, certain falcata varieties exhibit a spreading growth habit that involves adventitious shoots emerging from root tissue underground. This allows the plants to spread over large areas, with new plants surviving independently of the original plant, even if the main plant is damaged or severed (Heinrichs 1963). However, falcata varieties are generally lower yielding compared to hay-types and often exhibit undesirable agronomic traits, such as prostrate growth, strong fall dormancy, and seed pod shattering.

Our rangeland alfalfa breeding program is attempting to develop cultivars that are less fall dormant so that they will produce more forage during the rainy season in California. For any region that only has limited freezing conditions, cultivars with less dormancy will grow throughout winter whenever temperatures are high enough for growth (> 40° F). In addition, we are selecting non-dormant alfalfa for (1) tolerance to grazing, (2) the ability to survive summers with no water (irrigation or rainfall), and (3) compatibility with grasses. We are also attempting to understand the genetic basis of the spreading root trait, with an aim of introducing this trait into nondormant rangeland adapted alfalfa.

CONCLUSIONS

In California's Mediterranean climate, which is characterized by winter rainfall and dry summers, breeding alfalfa with reduced fall dormancy could help align plant growth with the winter rainfall that occurs in the region, leading to a more reliable forage supply and improved livestock production from rangelands. This breeding program aims to enhance alfalfa production in California, and to acknowledge the ecological and economic benefits of growers incorporating alfalfa into California rangelands.

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