Weed Management Affects Pasture Productivity and Animal Performance

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Abstract.
Weed can be defined as any plant growing in undesirable locations. Weeds are considered one of the main challenges in agricultural fields. Weeds affect pasture productivity mainly because of the competition for limited resources such as nutrients, water, and light with forage plants. Weeds encroach pastures spontaneously and spread quickly through the farm and neighboring areas, making their control difficult. In addition, weeds can affect forage nutritive value, grazing behaviour, voluntary forage intake, animal health, and consequently animal performance. The low efficiency of mechanical weeding and the global concern about indiscriminate use of herbicides impose challenges for producers in grazing systems. These factors justify the importance of proper weed management to minimize financial losses and environmental impacts and drive the research effort in this area. Currently, some strategies including grazing management, grass and legumes integration, and site-specific weed spraying have demonstrated potential to improve the efficiency of weed supression and increase the productivity and profitability of livestock systems. This review aims to discuss about the main effects of weed encroachment in grasslands regarding pasture productivity and animal performance, as well as emphasize potential strategies for weed management.

Introduction
Weeds can be defined as any plant growing in an undesirable location and are considered one of the main challenges in agricultural fields (Hamuda et al., 2016). Weeds in general are less demanding in soil fertility than forage species, they are typically locally adapted, and have, in many cases, a large seedbank. Besides, they do not require management practices to grow in grasslands, they are typically not grazed, and frequently encroach pastures spontaneously, spreading to other neighboring areas, making their control difficult. Weed encroachment represents one of the major sources of economic losses and environmental damage in agricultural systems (Ekwealor et al., 2019; Pimentel et al., 2001).

Spiny pigweed (*Amaranthus spinosus* L.) is an example of a weed found in grassland areas worldwide, highly disseminated in the state of Florida (USA), and is considered challenging for producers due to the high invasive potential and difficulty of control. Spiny pigweed usually produces large amounts of low-density seeds, which makes it easier to spread through animals or agriculture implements. Brush is another example of highly invasive weed plants and once they establish in pastures, create light competition with herbaceous forages. Their deep root system brings ecological advantages and competes with grasses. Coffee senna (*Senna obtusifolia*), dogfennel (*Eupatprium capillifolium*), tropical soda apple (*Solanum viarum*), and smutgrass (*Sporobolus indicus*) also could be mentioned as examples of pasture weeds spread around the world. In general, weed seeds can be spread by livestock and reduce the land value (Hogan and Phillips 2011). Some of them are also poisonous and can kill animals.

In this context, this review aims to discuss the main effects of weed encroachment in grasslands regarding pasture productivity and animal performance, as well as emphasize potential pathways to overcome the main issues related to weed management. The present review was outlined in three topics: effects of weed encroachment in grasslands, challenges for weed control in grazing systems, and alternatives for improved weed management and site-specific control to increase the production efficiency of grazing systems.

Effects of weed encroachment in grasslands

Weed encroachment affects pasture productivity mainly because of the competition for limited resources such as nutrients, water, and light with forage plants (Herbin et al., 2020). According to Nurjaya and Tow (2001), the loss of productivity of pastures from weed competition can be explained by morphological and physiological traits such as leaf area index (LAI), growth rate and root mass, which affects the capacity of plants to capture growth resources. Corroborating that statement, Tozer et al., (2011) reviewed the key factors leading to poor persistence and weed encroachment on pastures and found a negative effect of weeds on seedling growth and tiller production of forage species. The reduction of pasture productivity also could be attributed to allelopathy, where secondary compounds inhibit germination and growth of other plants (Ghanizadeh and Harrington 2019). Allelopathy is generally considered less impactful than competition (Fernandez et al., 2016).

Weeds can affect forage nutritive value and increase the proportion of less nutritive plant parts (e.g., stem), affecting the performance of grazing animals. Marchi et al., (2019) demonstrated that weed presence can affect grazing behavior, reducing forage intake. In addition, the presence of weeds also can impact animal health because of toxic compounds or physical damage (Townsend and Sinden 1999). Poisonous plants may contain one or more of hundreds of toxins from nearly all major chemical groups, including alkaloids, glycosides, saponins, resinoids, oxalates, and nitrates (Kingbury, 1964). The ingestion of some toxins can provide an inadequate diet, reducing productivity and quality of animal products, affecting reproduction performance, and even kill animals (Zimdahl, 2004). Spiny weeds for example can hurt the animals, depreciating the value of the leather, or even hurt the udder and teats of lactating cows causing potential mastitis and loss of productive potential.

In summary, weeds are responsible for financial losses in agricultural production directly and indirectly (Ekwealor et al., 2019). Weed encroachment imposes costs (more inputs) and labor for control. In addition, weeds reduce the system profitability though the reduction on herbage productivity, lower stocking rates and potential risk for the animals.

Main challenges for weed control in grazing systems

Pasture weed encroachment is usually controlled by mechanical weeding (mowing) or herbicide application. Although biological control also could be considered, the use of biotic agents (e.g., plants, herbivores, insects, nematodes, and phytopathogens) to suppress weeds still needs further study for large-scale implementation. Mowing is time-consuming, laborious, and less effective compared to herbicides application because it allows weed regrowth. These factors make mechanical control more expensive as well, since it requires more labor and frequency of management. However, there is a growing global concern with the use of herbicides because of environmental impacts of the chemical application. In some cases, weeds can become resistant to herbicides. Finally, chemical applications represent high cost for producers to spray large pasture areas. Pasture areas are frequently of large extent and sometimes are difficult to access for manual or mechanized weeding. These constraints reduce the efficiency of weed control because of the difficulty of treating large areas in time to prevent weed plants flowering to avoid seed spreading. On the other hand, the difficulty to find species-specific herbicides to apply in established pastures, herbicide costs, and environmental impacts of herbicides spraying large areas also imposes challenges for farmers.

Alternatives for improved weed management

Recent studies have demonstrated some alternatives for improved weed management and greater production efficiency of grazing systems. Low pasture productivity can increase weed infestation because of the lack of competitiveness, while proper pasture management reduces the opportunity for weed emergence. Suitable stocking rate and maintenance of a sward structure favorable to animal intake are important for weed management and efficiency of the grazing system. Under integrated crop-livestock systems for example, the use of cool-season cover-crop grazing has been recommended to offset the land fallow after crop harvesting in September-October, as well as reduce the weed encroachment. The soil cover

can reduce erosion and weed encroachment because of the physical barrier to weed emergence, simultaneously providing fodder for grazing animals. However, grazing intensity must be adjusted according to the forage allowance to avoid overgrazing and weed encroachment. Schuster et al., (2016) evaluated the effects of different grazing intensity on weed seedling emergence and seed banks in a cover crop system under no-tillage and concluded that decreasing the grazing intensity reduced the number of weed species, the density of emerged weed seedlings, and the weed seed bank density, suggesting that higher sward heights help to control the weeds. It is important to mention that the grazing intensity recommendation also should consider particularities of each system, such as forage species and animal requirements, since that the excessive forage growth can reduce the biomass during the subsequent season and increase the forage stem proportion, reducing forage nutritive value and animal performance (Schuster et al., 2019). Additionally, recent studies also have shown that increasing species diversity in grassland communities, especially by mixing grass and legumes, is associated with lower weed biomass and can suppress weed growth better than monocultures (Latif et al., 2019).

In addition to grazing management and integration of legumes in the system, site-specific weed control could be an important alternative to reduce the cost of herbicides applied and minimize environmental impacts. Advances of precision technologies and artificial intelligence allows weed detection based on image classification using machine-learning techniques. This approach enables spot spraying by drones or tractors. Petrich et al., (2020) demonstrated that low-cost cameras on drones and machine-learning techniques were able to detect 89% of a poisonous weeds in grassland sites. Similarly, Lam et al., (2021) also demonstrated potential of drone systems and machine learning for automated weed detection in grasslands. Findings of Zou et al., (2022) support these previous studies suggesting that neural networks could be used to assess the density of each weed species in a complex multi-species environment providing a reference for herbicide selection and accurate spraying.

In general, the literature reviewed suggests that integrated weed management, combining grazing management, species selection, and site-specific herbicide spraying is the best approach to reduce weed encroachment and increase pasture productivity and animal performance in grazing systems.

Concluding remarks

Weed encroachment reduces livestock output per area by affecting forage productivity, forage utilization, forage nutritive value, voluntary intake, and animal health. Grazing management might reduce weed encroachment as a preventive approach, but once weeds are established, they must be managed. New precision technologies, such as drones and artificial intelligence can be used for spot spraying to improve weed control efficiency and system productivity.

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