

FACTORS AFFECTING FORAGE STAND ESTABLISHMENT

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ABSTRACT: Significant advances have been made in our knowledge of forage seed physiology, technology, and stand establishment practices; however, stand establishment continues to be one of the most common production problems affecting forage crops in the USA. There is a need for research on stand establishment of forage crops under abiotic and biotic stress. Although the forage seed industry produces and markets seed of high quality, new methods of assessing seed vigor are needed and their use should be expanded in the industry to enable matching seed lot performance to specific environmental conditions where performance can be maximized. Seed treatment and seed coating are used in the forage seed industry, and studies have shown they are of benefit in some environments. There is an increase in no-tillage seeding of forage crops, but improvements in the no-tillage planting equipment are needed to make them better suited to small seeds. Other recent developments in seeding techniques include broadcasting seed with dry granular and fluid fertilizers, which improves the efficiency of the seeding operation.

Key Words: planting, seed coating, seed quality, seed treatment, seed vigor

FATORES QUE AFETAM O ESTABELECIMENTO DO ESTANDE EM PLANTAS FORRAGEIRAS

RESUMO: Progressos recentes têm sido obtidos nos conhecimentos referentes a fisiologia, tecnologia e práticas para o estabelecimento do estande, em espécies forrageiras. No entanto, o estabelecimento de estandes adequados ainda se constitui em um dos problemas mais freqüentes para a produção de forrageiras nos Estados Unidos. Há necessidade de pesquisas sobre esse assunto, principalmente quando as sementes são expostas a estresses abióticos e bióticos. Embora a indústria de sementes forrageiras produza e comercialize materiais de alta qualidade é necessário o desenvolvimento de novos métodos para a avaliação do vigor. A utilização desses testes necessita ser incentivada, para permitir a associação entre o desempenho de lotes de sementes e condições ambientais específicas, onde o desempenho pode ser maximizado. O tratamento e a cobertura de sementes com películas são usados pela indústria de sementes forrageiras; pesquisas têm demonstrado benefícios desses procedimentos. Têm sido constatados acréscimos das áreas de culturas forrageiras semeadas sob o sistema de plantio direto; no entanto, há necessidade do aprimoramento dos equipamentos destinados à semeadura direta, visando adequá-los ao trabalho com sementes pequenas. Outros desenvolvimentos recentes nas técnicas de semeadura incluem a distribuição de sementes com fertilizantes granulados e/ou fluidos visando beneficiar a eficiência da semeadura.

Descritores: sementes, semeadura, cobertura com películas, tratamento, vigor

INTRODUCTION

The establishment of a uniform and vigorous stand is of paramount importance to the successful production of most crops. Without a good stand, the effectiveness of other agronomic inputs is drastically reduced, and usually such inputs can never compensate for the negative impact of a poor stand. With perennial forage crops, failure to achieve a dense stand at initial planting can have long-lasting consequences compared with annual crops. This is especially true for seeded annual and perennial forages

that exist as discrete plants (e.g., alfalfa [*Medicago sativa* L.] and lovegrass [*Eragrostis* spp.]) (Miller & Stritzke, 1995). Obtaining dense stands from initial plantings of forages which vegetatively propagate (e.g., through rhizomes or stolons) is less critical; however, establishment of healthy plants that are able to compete and withstand abiotic and biotic stress is still very important with those species.

This paper focuses on aspects of seed quality, seed enhancement, and recent developments in stand establishment practices of temperate forage crops grown in crop rotations in the USA (e.g., perennial

grasses and legumes grown for hay or short-term pastures). The improvement of long-lay permanent pastures and rangelands through artificially enhanced and natural processes of seedling recruitment of desirable species is beyond the scope of this paper.

SEED QUALITY

The importance of quality seed to successful forage establishment cannot be minimized. Several authors have recently reviewed aspects of forage seed development, processing, germination, and quality (Hill et al., 1997; McDonald et al., 1996; Simon et al., 1997). The forage seed industry in the USA delivers good quality seed to the market place; however, from a practical stand establishment perspective, there is a need to improve and more widely utilize methods of assessing forage seed vigor.

The standard germination test does not relate well to actual field emergence (Assoc. Off. Seed Anal., 1983), particularly when emergence conditions in the field deviate from optimal. Seed lot vigor becomes very important when environmental stresses occur at sowing (Hill et al., 1997). Forage seed lots with high germinability often differ in vigor, resulting in reduced establishment, dry matter production, and performance in storage (Hampton, 1991). Seed vigor may also influence nodulation and dinitrogen fixation in forage legumes, as in field beans (*Phaseolus vulgaris* L.) (Rodriguez & McDonald, 1989). An effective assessment of seed vigor would be useful for positioning of seed lots in the market place. For example, seed vigor tests might help identify which seed lots would perform best under the cold and wet spring planting season as opposed to the warm and drier late summer planting season.

Research on vigor testing of forage seed lots has received little attention compared with that conducted on other species. Several researchers have evaluated the use of accelerated aging and the conductivity test for forage seeds (Clark, 1982; Hall & Wiesner, 1990; Hampton & Bell, 1989; Helmer et al., 1962; Hampton & TeKrony, 1995; Wang and Hampton, 1993). Standardized procedures for these tests have been developed for several forage species, and hopefully their use will increase and assist the industry in assessing seed lot planting value of seeds for different markets. Hall & Wiesner (1990) concluded that a combination of tests which include both physiological and biochemical measures of seed quality should be used in adequately assessing seed vigor. This promises to be a fruitful area of research

with potential to provide real and practical benefits to forage producers.

Seed dormancy in forage grasses and hard seed content in forage legumes are two important factors affecting the stand establishment. In nature, these mechanisms ensure a broad, dormant soil seed bank capable of germinating when favorable conditions are encountered for growth and establishment (McDonald et al., 1996). They also ensure that not all seeds germinate solely on a single environmental cue, but that continued emergence and establishment of the species occurs under a variety of habitats and environments (McDonald et al., 1996).

Although seed dormancy is advantageous in nature, production agriculture demands that seeds planted germinate uniformly and quickly to produce a productive stand. Therefore, various mechanisms are employed to break seed dormancy. McDonald et al. (1996) described these methods for grasses, including KNO_3 , light treatments, and prechilling. Various methods can be used to decrease hard-seededness in forage legumes (Bass et al., 1988), but mechanical scarification is probably the most commonly used in the industry. Mechanical scarification injures seeds, thus resulting in higher abnormal seedling counts and deterioration of vigor and viability. A recent study demonstrates that scarification may not always be necessary to ensure adequate field performance of forage legume seed lots with high hard seed content (Albrecht et al., 1996). Alfalfa seed lots with hard seed levels of up to 50% had no significant impact on total seedling emergence, establishment year forage yield, or forage yield the year after establishment. Rate of emergence was reduced slightly by high levels of hard seed. Scarification increased rate of emergence of most seed lots, but had no effect on forage yield. These results indicate that it may not be necessary to mechanically scarify alfalfa seed lots with moderate levels of hard seed content in order to ensure good performance in the field. There is a need for further study on factors governing hard seed expression under natural field conditions, and methods developed which adequately predict field germination and emergence of forage legume seeds.

SEED ENHANCEMENTS

Various seed enhancements have been evaluated for improving planting value and quality of forage seeds. These include various seed treatments, seed coating, pelleting, and controlled hydration (refer

to McDonald et al., 1996; Johnson, 1975). Unfortunately, the high cost of some of these enhancements has limited their commercial use in forage seeds. Forage seeds have a lower expectation of return compared with vegetable and flower seeds; thus the additional cost of any seed enhancement must be low in order for a profit to be realized. Seed treatment and seed coating have been the most widely used enhancements in the forage seed trade, as evidenced by the amount of commercial investment into these processes (Ni et al., 1998; Simon et al., 1997). As the cost of other types of enhancements is reduced, their use in forage seeds will likely increase.

Seed treatment in forages involves primarily the application of fungicides or insecticides, and bacterial inoculants in the case of nitrogen-fixing legumes. Seed treatment is now a very common practice in the forage seed industry in the USA, particularly with alfalfa seed. Seed coating involves the addition of either inoculant, fungicides or insecticides together with other substances to provide a protective barrier over the seed. The current coating process in the forage seed industry employs limestone coating and a bacterial inoculant in the case of legume seed (Ni et al., 1998). A systemic fungicide is often added in the coating process, usually metalaxyl [*N*-(2,6-dimethylphenyl)-*N*-(methoxyacetyl)alanine methyl ester] for the control of *Pythium* and *Phytophthora* spp. Nutrient elements may also be included in some cases. The normal coating percentage is 33% for small-seeded legumes (i.e., seed:lime ratio=2:1) and 50% for grass seeds (i.e., seed:lime ratio=1:1). Usually all the ingredients are added to the seeds in one step.

Seed coating of alfalfa has been shown to improve *Rhizobium* survival and early nodulation of seedlings (Horikawa & Ohtsuka, 1995a, 1995b; Sheaffer et al., 1988). Coated alfalfa seed has not shown a consistent advantage over uncoated seed in terms of higher stand densities and forage yields. Some studies have demonstrated significant improvements in stand establishment and forage yield while others have demonstrated mixed results across different environments (Canestrino et al., 1998; Horikawa et al., 1996; Twidwell & Gallenberg, 1993; Sheaffer et al., 1988; Marble et al., 1990). The decision on whether to use an alfalfa seed enhancement should be based on soil type, field history of disease problems, and cost of the treatment (Twidwell & Gallenberg, 1993). Johnson (1975) indicated that further research is still required to determine the specific situations in which coating and pelleting may be of value in improving

rangelands. Methods of reducing the cost of seed enhancements are needed so the industry can justify its cost on seeds having lower margins of return.

RECENT DEVELOPMENTS IN FORAGE STAND ESTABLISHMENT TECHNIQUES

Considerable research has been conducted on stand establishment of forage crops. There are numerous effective methods of establishing forage crops, but all employ several key principles which ensure a favorable environment for seed germination and seedling establishment. These include proper seed placement, good seed-soil contact, proper time of planting, adequate seeding rate, minimizing competition from other species (e.g., weeds or companion crops), and protection from insect pests and diseases. A combination of cultural practices and genetic improvement has contributed to successful stand establishment.

In practice, poor seed placement in the soil is probably the most frequent factor leading to establishment problems. In such cases, the seed is either planted too deeply or adequate coverage and good seed-soil contact are not provided. These problems usually occur because of poor seedbed preparation and/or inadequate adjustment of planting equipment. Recent advances in planting equipment have focused primarily on planting of large-seeded row crops. In some cases, these "improved" planters are less suited to planting small-seeded crops than the older equipment.

The advent of no-tillage planters has resulted in an increased interest in reduced tillage and no-tillage seeding of forages. Forage establishment using no-tillage techniques is not a new practice, having been used in renovating pastures. But the wider use of no-till planting equipment in row crops has increased the opportunity for no-till seeding for establishing new forage stands. No-till seeding presents important challenges in stand establishment. Seed-soil contact is probably the biggest challenge in no-till systems, especially since most temperate forage species have very small seeds. Further improvements in no-till planting equipment are necessary to achieve consistent success with forage seeds. Most no-till planters were designed for larger-seeded crops. The Truax drill is one example of a no-till drill designed specifically for grassland species, with the ability to handle very diverse seed types. It has not been widely adopted in regions of the USA where forages are grown in rotations with row crops because of its high cost

and lack of adaptability to seeding large row crop species.

No-tillage seeding of forage legumes has also increased the incidence of *Sclerotinia* crown and stem rot, one of the most destructive diseases of forage legumes in the eastern and southern USA. This fungal disease can completely destroy newly established stands, and is more prevalent in late summer seedings which are established using no-tillage and reduced tillage methods. Breeding for resistance to this disease and management practices to reduce its incidence are in progress (Sulc & Rhodes, 1997).

Modified grain drills and cultipacker seeders are considered the most reliable seeding implements for small forage seeds; however, some producers consider them expensive and too slow for seeding large areas. The old seeding technology of broadcasting seed has recently been modified by innovative producers seeking to increase the efficiency of forage seeding (Barnhart, 1998). Commercial and farmer-owned dry fertilizer spreaders, which are capable of delivering material over a very wide swath, are used to rapidly broadcast a blended mixture of dry granular fertilizer and seed. The most modern dry fertilizer applicator equipment uses flowing air to move the dry fertilizer material through a manifold and a series of pipes to provide a more uniform distribution of material than is possible with the older "spinner" spreaders. This technology requires well-prepared and firm seedbeds before broadcast spreading, followed by the use of cultipackers (rollers) to provide shallow seed coverage with the desired seed-soil contact. Forage legumes and cereal seeds are the most common species seeded with this method.

With the resurgence and improvements in broadcasting seed with dry fertilizer, the development of broadcast sowing of legume seeds with fluid fertilizers soon followed. A significant portion of the fertilizer applicator industry has adopted the sale and distribution of fertilizer in the fluid form. The fluid fertilizer applicators have the ability to broadcast free-flowing liquids or finely divided fertilizer material suspended in water, often with a clay-based suspension carrier. A variety of materials can be blended and accurately metered across a wide swath (18 meters). Through trial and error, fluid fertilizer applicators have perfected an efficient fluid seeding system: all screens are removed, 2 to 3% clay is used with a minimum of 470 to 560 L ha⁻¹ of fluid fertilizer (or 3 to 4% clay is used with water), the clay/fluid suspension is agitated for 0.5 hr, and the desired amount of legume seed is added to the agitating suspension in

the tank, and then applied immediately to the field. Large flood-jet nozzles are required. As with dry fertilizer seeding, conventional tillage must be used to prepare a clean, firm seedbed before application, and the field must be cultipacked after the seed is applied to provide shallow seed coverage and good seed-soil contact.

Seeding legume seeds with fertilizer led to concerns of a detrimental "salt effect" of fertilizer on alfalfa seed germination, seedling vigor, and *Rhizobium* inoculant survival. Limited greenhouse studies (Evers, 1986) demonstrated that seed germination and seedling vigor of forage legumes began to decline after 12 to 18 hr when in contact with granular fertilizer. The fate of *Rhizobia* on the seed or nodulation was not monitored in those studies. Johnson (1997) evaluated performance of alfalfa seed in fluid fertilizer suspensions. From bacterial culture, controlled environment, and field studies, he concluded that *Rhizobium* death and alfalfa seed emergence with use of 4-10-10 and 10-34-0 fluid fertilizers as carriers should not be a concern to the producer. Seeding alfalfa with fluid fertilizers should be considered if timeliness of operation can be improved and corrective nutrient needs met with the fertilizer application.

CONCLUSION

Although advances have been made in our knowledge of forage seed physiology, technology, and stand establishment practices, there is much room for improvement. Stand establishment continues to be one of the most common production problems of forage crops in the USA. We have mastered the establishment of forages crops under good conditions, but forages are often grown on marginal and less productive soils than row crops. Abiotic and biotic stresses are exacerbated on these less productive soils. There is a need to more thoroughly understand the factors affecting forage stand establishment under biotic and abiotic stress so that means of improving establishment success can be developed. Undoubtedly improvements in stand establishment will result from advancements in seed quality and seed enhancements, genetic improvement, as well as improved seeding techniques.

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