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Review

Re-seed or not re-seed? Factors affecting rangeland grass-seedling establishment. Review

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Abstract:

Although seedling has a significant role in the maintenance of plant diversity, productivity, and biochemical cycles in the rangeland. However, little is known about the influence of environmental factors in the seedling establishment, as well as the differences in the morphological development among species. To understand of seedlings establishment becomes of crucial importance to improve the success of reseeding of natural ecosystems. This literature review investigated which factors are addressed with failures in the seedling establishment of native grasses in rangeland conditions. Germinating seed grass is not big a problem if there are optimum environmental conditions. The heart of the matter is to ensure the survival and growth of these seedlings until the complete establishment as plant. The moisture and temperature of soil are the main environmental factors associated with failures in seedling establishment. The studies reviewed showed that annual plants have higher seedling growth rates, however lower allocation to reproductive structures when compared to mid-seral and late successional plants. These differences also promote different rates of seedling survival rate, with early seral grass showing higher rates than late seral. Apparently, the main cause of seedlings failures in the establishment is correlated with the development and extension of the adventitious roots. Where the reports describe that seedling emerge quickly and abundantly in most grasses, but the seedlings died between six and ten weeks of age. It was addressed that a plant can germinate and sprout the primary roots, however, for an unknown reason the plant does not sprout the adventitious root.

Keywords: Rangelands, Adventitious root, Rangeland restoration, Seedling establishment, Rangeland reseeding.

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Introduction

Rangelands are widely diverse, including grasslands, savannas, shrublands, deserts, tundras, marshes, and meadows. Rangelands cover about 50 % of land area in the world. Only in north America stats indicates that 1.3 billion of hectares can be classified as rangelands[1]. During the last century, the man has increased the ways to use rangelands due to expansion of croplands, urbanization, and mainly the expansion of livestock production. Overuse of these ecosystems promotes a non-natural phenomenon denominated “Rangeland degradation.” There are two factors that might cause rangeland degradation: natural cycles lead by droughts, and the second one, related to human factors addressing the overuse of natural resources.

The effects of climate catastrophes and human land use promote the depletion of soil nutrients, and decline in water retention, causing a breakdown in soil structure, and therefore the changes in vegetation composition, increasing the percentage of less desirable plants for the livestock, such as thorny and low palatable plants. Also, intensification of land use without proper rangeland management reduces biomass productivity, which may lead to further agricultural expansion in even more marginal areas.

D’Odorico, *et al*[2] mentioned that among the human activities that degrade rangelands, overgrazing as the main factor for the losses of forage species diversity on rangeland. The fast increase of the world’s livestock population has been causing overuse of rangeland. Overgrazing of rangelands initially reduces biomass productivity, breaking all natural bio-cycles in the ecosystems. Overall, overgrazing converts the rangeland into a desert place (desertification). Currently worldwide more than 680 million hectares of rangelands are in some degradation stage, which is five times more than the U.S. cropland area, or 100 times the agricultural land area of México[3], Gaitán *et al*[4] affirm that continuous grazing with excessive stocking rates has been occurring for many decades over all rangelands of the America.

The previous situation has encouraged several projects aiming to mitigate the effects of rangeland degradation, including the reseeding of the rangelands with native and exotic plant species. It is important to mention that currently, most of the projects recommend reseeding exotic species, believing in an increasing stocking rate. However, in some initiatives, for example, in México and Argentina, reseeding attempts to restore the ecosystem to a condition near the original, thus, to recover the natural landscape conditions, the Plan Maestro de la Alianza Regional para la Conservación de los Pastizales del Desierto Chihuahuense in México and the Buenas Practicas Ganaderas in Pastizales of the Argentina government, have become as mandatory in reseeding programs the use of only native species.

Johnson *et al*[5] affirms that reseeding native forage grasses increase the percentage of desirable grass species in the rangeland, increasing the forage available to livestock and wildlife, and consequently a higher stocking rate. Nonetheless, some reseeding projects in several parts of the world (such as Mexico, USA, Canada, and Argentina) are trying to compensate for the loss of plant diversity using native grass species. However, the high cost and risk involved in the process of reseeding and the lack of knowledge of the physiological mechanisms in seedlings seem to be a big obstacle to the success of this practice. In addition, Rector[6] mentioned that the high risk of reseeding rangelands is associated with the temporal and spatial unpredictability of rainfall pattern in many rangelands during the seedling establishment period.

The chance of success decreases dramatically in semiarid zones due to the short rainfall season. Rector[6] also states that the rate of success in reseeding programs is more effective in areas with annual rainfall superior to 800 mm/yr. Conversely, in areas with precipitation inferior to 350 mm per year the probability of risk of failure in seeding establishment is more than 80 %. According to the Plan Maestro de la Alianza Regional[7] rangeland reseeding promotes multiple benefits, such as 1) Increasing plant diversity; improving forage quantity and quality for livestock; 2) Producing large or abundant seeds for wildlife; 3) Promoting a beautiful spring view, and 4) Facilitating soil stabilization in disturbed areas. If all environmental conditions (soil temperature and moisture) are met, germinating of a seed grass will be completed. The problem is to ensure the survival and growth of these seedlings until the entire establishment as plants; in México the the occurrence of the intra-seasonal drought and early frosts in the rangelands affect the seedling estableshment. After a considerable number of papers reviewed, it was regard to seedling establishment failure and addressing by not ideal conditions to germinate seedling grass.

Orloff *et al*[8] point out the three major factors associated with seedling failures on rangeland grasses during the establishment: inadequate environmental conditions, seed size, and genetic factors. About the genetic factor Esau[9] and Tischler *et al*[10] reported that seedling establishment is correlated with the ability to initiate growth of adventitious roots and the subsequent elongation of these roots in the seedling stage. Regarding the environmental factors associated with the seedling establishment in perennial grasses, most of the published literature mentioned four factors as the most important for seedlings establishment: 1) Inadequate soil moisture, especially in the surface[11,12] 2) Inadequate environmental temperature, especially the soil temperature[13] 3) Competition for sunlight and nutrients among species[14] and 4) planting depth[15]. Concerning to environmental factors, Briske and Wilson[13] studied the optimum temperature and moisture in blue grama seedlings, and they conclude that even with optimum environmental conditions, some other unknown factors also affect seedling establishment.

Although this review aims to discern seedling challenges during stable development, it is essential to mention that some seed/germination limitations should also be overcome. Size and weight of seeds are also reported as a factor that affects the seedling development[15]. Maron *et al* [16] concluded that not only the size but also the weight of seeds influences the seedling survival of rangeland plants. Hyder *et al*[17] affirm that unknown genetic factors could also promote failures in the seedling establishment. In addition, other works[18] suggest that photomorphogenic factors associated with the seed and crown could cause failures. Several approaches have shown which mechanisms affect seedling establishment; however, all conclude that development and extension of adventitious roots is the most important process associated with seedling establishment. Therefore, in this review, it was discussed the main factors that cause failures in the seedling establishment of native grasses in rangeland conditions.

Environmental factors that affect the seedlings establishment and survival

There is no single environmental attribute that could entirely explain seedling vigor in grasses. Thus, environmental influences on seedling establishment in grasses should be analyzed together. Most literature indicates that interaction among moisture, temperature, and light are the main environmental factors that affect the success of seed germination and seedling survival.

Sluijs & Hyder[19] affirm that in blue grama, adventitious root grows out of tillering crowns and becomes successfully established when damp and cloudy weather persists for 2 or 3 d after germination. But if the roots are exposed to harsh environmental conditions the chances of survival are poor[20]. It is important to mention that each site has an optimum environmental condition for seedling establishment. The effect of environmental factors on seed germination of rangeland grasses has been broadly studied[21,22]. However, few studies tried to understand the impact of environment after germination until entire establishment (juvenile phase). In this segment of this review, the effect of environmental factors on seedling establishment will be discussing it.

Temperature

Temperature seems to have more influence on seed germination than seedling establishment. Overall, environmental temperature determines the rate of development in all organisms. Snyman [23] affirms that soil temperature is the major factor associated with seedling emergence because it controls evaporation and transpiration rate in ecosystems. It is affirmed that the ideal temperature of seedling growth for warm-season grasses is between 25 and 30 ºC[24]. While, for cool-season grasses, McGinnies[25] stated that a temperature around 20 ºC promotes the best root development in these species groups. By studying the effect of moisture and temperature in two grass and four forbs natives from north American grasslands, it was concluded that a temperature lower than 15 ºC resulted in delays in the seedling establishment caused by an inefficient root distribution in the soil[26].

Soil temperature seems to be more important than air temperature. Hsu *et al*[24] suggested that high soil temperature in the first 30 cm of soil is a major factor associated with failures in root emergence. Therefore, the faster the root reaches the deepest soil layers, the greater the chance of the plant surviving and establishing in the rangeland.

Hsu *et al*[24] affirm that the optimum soil temperature for root grows for warm-season grasses ranges between 9.4 and 11.4 ºC. However, this temperature is usually higher during the summer in all rangelands located between the parallels 30º N and 30º S[27], which probably is one of many factors associated with failures in the reseeding on drylands. Briske and Wilson[13] stated that for a successful seedling establishment in drylands the seedling roots of grass need to develop quickly in order to avoid the excessive exposure to high temperatures. The optimum temperature for shoot and root shows to be different. The optimum temperature for shoot growth for dryland grasses is around 5 ºC lower than the temperature for optimum root growth, causing a disbalance in terms of environmental condition[28].

Moisture

There is no doubt that moisture has an essential role for plants in the seedling stage. Moisture seems not to be limited in pasturelands, which can receive an additional water by irrigation. In contrast, rangelands, rainfall is the only source of water. The moisture in the soil is not a limiting factor to grass growth in tropical lands because the moisture in the soil of these regions is abundantly available for a large part of the year(29). However, this is a limiting factor for seedling establishment in semiarid and arid environments.

Concerning the U.S. rainfall pattern, Rajagopan and Lall(30) affirm that U.S rangelands western of the 100º of meridian longitude exhibit considerable complexity distribution temporal and spatial , in comparison to rainfall patterns in the eastern part of the country. Thus, an analysis based on annual or monthly precipitation for drylands does not allow conclusive results about water availability for the native plants.

It was mentioned that it is necessary to appreciate that rain precipitation does not imply that rainfall water will be available 100 % to the plants(31). Therefore, it is essential to understand the hydrology patterns and its implication in the ecosystem. Thus, this could be the initial step to comprehend the influence of environmental factors on seedling establishment. Some researchers(32) addressed the response of plants with pulses of precipitation. The pulses of precipitation theory suggest that frequency of precipitation has the same importance as the volume precipitated in some area.

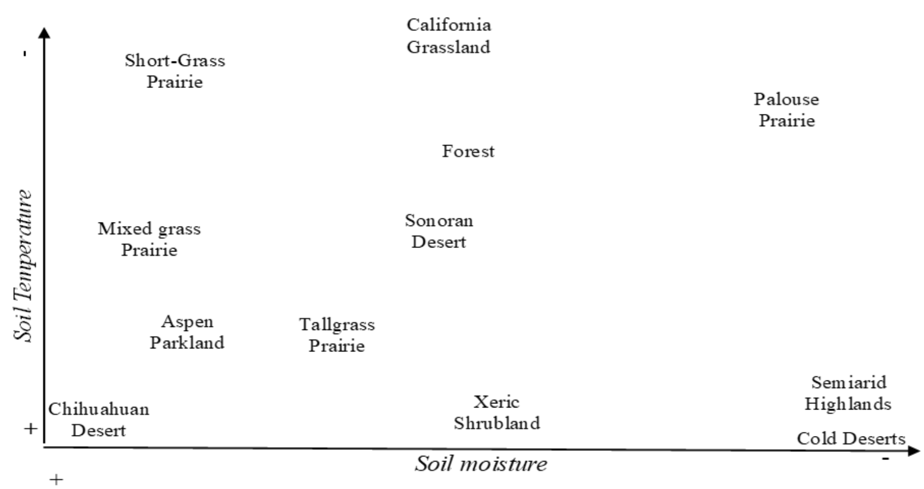
In one work(33) states that it is necessary to have two wet days for a grass seed to germinate and five wet days for the seedling to establish in rangeland conditions. After this time, the seedling can resist up to seven dry days consecutively. In arid lands, the growth of plants is primarily controlled by soil water availability than any other factor. Water has an intrinsic ratio with all aspects of grasses growth on rangeland species including anatomy, morphology, physiology, and biochemistry(34 –36).

The key for seedling establishment in rangelands seems to be a positive balance in soil water available. In other words, there should be more rainfall than evaporation in that area. Frasier *et al*(33) studied the effect of drought on sideoats grama seedlings and concluded that five consecutive dry days promoted mortality over 50 % of the seedlings. Drought and soil desiccation are the main factors for the limits of seedling establishment in many environments(37). It was suggested that differences exist in seedling survival among grass species during drought. The development and extension of adventitious roots play an important role in the plant establishment and soil exploration(38).

Studying blue grama, it was concluded that optimum moisture for maximum development of adventitious root is 90 % of soil saturation[13]. However, the adventitious root could grow slowly in low soil water potential conditions. Harrington[39] studied the effect of soil moisture on shrub seedling survival in a semi-arid grassland in Australia and concluded that to obtain success in the seedling establishment, it was necessary to apply at least 100 mm of supplementary irrigation during summer on three occasions after the pre-sowing irrigation in early spring and twice after late-spring irrigation. It is important to highlight that the author reached seedling survivorship above 80 % in irrigated plots when compared with zero survivorship on the unirrigated plots. Davis[40] affirms that most native species of the California chaparral have seedlings adapted to drought showing shallow-roots and high efficiency of water available. It was concluded that failures in the root establishment and development of 12 grass species of prevalent occurrence in the California chaparral occur during droughts in the summer[41].

According to some information[1] moisture and temperature in the soil are the most important factors associated with failures in the seedling establishment of grasses of North American rangelands. Thus, using this affirmation, we reviewed several articles which studied the influence of these two environmental factors on the seven main rangelands ecosystems of the United States. Figure 1 represents graphically the level of importance of moisture and temperature in the soil reported in the scientific literature associated with failures in the seedling establishment of grasses in the rangeland of North America.

Figure 1: Importance of soil temperature and moisture associated with risk of failures in the grasses seedling establishment of grass seedlings in the rangelands of North America *†



† The figure is based on results of 18 studies in the 12 rangeland ecosystems of North America. *The level of importance had been set based on several scientific reports which associate failures in the seedling establishment with soil temperature and moisture. Thus, the closeness of ecosystems (name) with signal (+ and –) represents graphically the level of importance of these variables in the ecosystem.

In the Chihuahua Desert the combination between soil moisture and soil temperature has a similar level of importance in the seedling establishment of rangeland grasses. On the other side, cold deserts and semiarid highlands we found more reports demonstrating a strong association between failures in the seedling establishment and soil temperature. In the xeric shrublands (e.g., Matorral xerofilo and Mesquitales of Mexico) the temperature of soil was reported more than moisture as cause of seedlings failures in the establishment. Similar pattern to tallgrass prairie and the Aspen parklands of Canada. For the rest of group, could also be noted that in the tall grass and mid-grass prairies, seems to exist a combination between these two factors that assure a successful development of rangeland grass-seedlings.

Others (light, soil, and planting depth)

The light can also control the seedling establishment because a low light intensity reduces the leaf and root size. Pang *et al*[42] affirm that shade could reduce the soil temperature, but it did not increase survival of grass seedlings. By studying the effect of shade in growth response of four perennial southwestern grasses it was concluded that morphological, physiological, and yield responses were high in plants in full sunlight condition than plants under different levels of shade[43]. Although the light affected the size of leaves and roots, this variable did not affect the seedling establishment directly.

Concerning soil properties that affect seedling establishment, the hydraulic conductivity seems to be the most important, in other words, the capacity of moisture retention and water availability to the plants. Okami[44] stated that hydraulic conductivity is the most important soil variable related with grass seedling development, once that 75 % of the time during the seedling establishment, the seedling is not dependent on nutrient content in the soil. The physical soil features such as texture, structure, density, and capillarity determine the water retention in the soil and the contact surface between soil moisture and the seed. Berti and Johnson[45] studied the seedling establishment of switchgrass in different soil types, and they concluded that seedling emergence is 25 % faster in sandy soil than in clay soils. Similar results stated that soil texture affected seedling emergence in some tropical grass[46].

Planting depth also has been reported as a factor that influences the development of seedlings in grasses. One report[11] affirm that planting depth affects the seedling establishment of rangeland grasses, especially during the emergence stage. Analyzing the influence of planting depth in the seedling emergence of native grasses it was stated that Bromegrass (*Bromus inermis*) planted deeper than 1.3 cm in a silty clay loam soil decreased the emergence, and consequently seedling survival[47]. While other authors[11] studied the influence of planting depth on the emergence, morphology, and establishment of big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*). They concluded that results obtained from these experiments were not convincing to affirm that planting depth affects the seedling survivorship. In arid condition the switchgrass, had the higher emergence when planted under pre-sowing irrigation and shallow seeding(48). Anderson(49) affirms that optimum planting depths from native grasses of northern US and southern Mexico are between 6 to 12 mm, the difference inside this range is according to grass species and soil type.

Differences in the rate of utilization of seed reserves may explain why certain species emerge at greater planting depths than others. Others authors suggested that optimum planting depth is correlated with the amount of carbohydrate reserves content in the seed(50-52).

Non-environmental factors that affect the seedling establishment

Plants have several anatomorphological adaptations to be more effectively to compete with each other plants for resources (light, water, nutrients, soil, and air). Harris(53) stated that in a general concept the perennial grasses have a natural competitive advantage over annual grasses, so that, it is not necessary for them to seed following each dormant period. However, annual plants have a fast-seedling establishment.

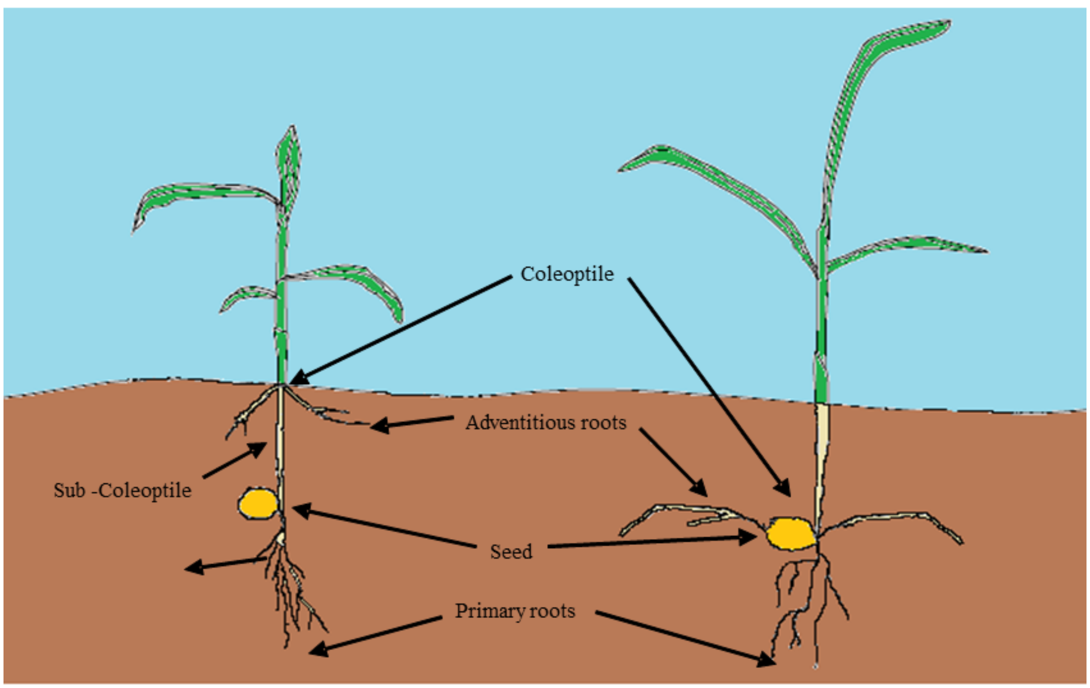
Thus, by studying the influence of growth form and plant morphology in the seedling establishment of dryland grasses, researchers. concluded that neither variably affected emergence, survival, nor relative growth rates in all growth forms studied(54). Corroborating with authors mentioned above Larson *et al*(12) affirm that variation in anatomy, morphology and physiology among seeds and seedlings explained over 90 % of the variation in cumulative survival of rangeland grasses, regardless of seedling survival probabilities or precipitation pattern.

There are three major non-environmental factors related to seedling establishment: morphology, physiological and genetic characteristics intrinsic for each species (seral stage) and competition among species(21). Below was done a brief review of how these factors affect the seedling establishment in rangeland grass species.

Morphology

Grass seedlings are hypogeal, which means that the cotyledon in most cases remains below ground during the germination. The elongation of the coleoptile is different between cool and warm season grasses. In the cool season grasses, the coleoptile is long with short sub-coleoptile; contrarily the warm season grasses have a short coleoptile and short sub-coleoptile (Figure 2).

Figure 2: Seedling morphology (right festudicoid plant); left (panicoid plant)



(Adapted from Tischler *et al* 1989).

The extension of coleoptiles and sub-coleoptiles have an important role in the emergence of seedlings because near the top of these structures are located the meristematic points where the first leave will grow(55). The roots are also important in the seedling establishment; it was reported(56) that the root system in seedling grasses consists of seminal and adventitious roots. The seminal roots start to grow immediately after germination; they arise directly from a structure in the seed called scutellar note. The seminal roots are divided into primary roots and lateral roots. Seminal roots are entirely dependent on adequate levels of water content in the young plant, as well, moisture in the soil(57).

After the entire development of seminal roots, the seedling starts to release the adventitious root from the coleptilar node. Tischler and Voight[9] affirm that adventitious are considered the mature root system. Some authors suggest that establishment of seedlings is associated with the development of adventitious roots[56].

The seminal roots start growth after 1 or 2 consecutive wet days; once the seminal roots are developed, plants begin to sprout the adventitious root. This phase is called the transitional stage. In other words, the transitional stage consists of development and extension of the adventitious root, and a weakening and death of the seminal root[58]. Hyder *et al*[17] affirm that in field conditions where blue grama seedlings fail in the extension of adventitious roots, the seedlings die between 6 to 10 wk of age. It was stated that for a successful seedling establishment, the rate of root elongation of adventitious roots should be sufficiently fast to keep a portion of the root in moist soil ahead of the drying soil[13].

Newman and Moser[11] advocate that adventitious root development undoubtedly controls the seedling establishment. However, little is known about how many, and extensions of adventitious roots will be enough to affirm when a plant is established. Even though some authors associate the establishment of seedlings with the transitional stage, it was mentioned that the development and activities of roots of cultivated grasses and concluded that the seminal roots remain alive and active until the time of harvest in crop plant species[57].

After examining reports about root systems of 14 perennial grasses, conclude that in these species the seminal root grew deep and spread widely, and they remained alive and active as absorbing organs during four months of experimental analysis[13]. Most of the articles reviewed affirm that adventitious root development in the transitional stage determines the seedling establishment, and the death of seminal roots is required for the development of adventitious roots. However, there is not a consensus about this hypothesis, since some researchers indicate that seminal roots remain alive for a long time after the plant reaches the mature phase.

Competition between species

The competition among plants occurs when the demands of neighboring plants exceed the resource supply, inducing the stress and then the death of the plants. Plant completion could occur in two levels, among individuals in the same species (inter-species) or among individuals of different species (intra-species). Whatever the level, competition affects the availability of environmental resources for plants. It was reported[59] that initial densities and timing of establishment promote changes in the dynamics of plant competition because they lead to asymmetries in plant size and resource capture. Range plants have many adaptations (morphological, anatomical, physiological, and phenological) suiting them to a place in the ecosystem. Therefore, understanding the effect of competition among species is a basic requirement to increase the chances of success of rangeland reseeding.

Stands of perennial grasses have a natural competitive advantage over annual grasses. Since it is not necessary for them to begin from seed following each dormant period[(24)]. Ries and Svejcar[(60)] reported that seedlings of annual plants readily invade and become established on disturbed sites. Favorable root phenology is one of the adaptive strategies allowing this superior competitive ability.

Some authors[(61)] defines five most important phenological characteristics in seedlings concerning competitive relationships in juvenile plants. The features are (1) easy germination, (2) precocious initial root growth, (3) rapid extension of root-soil contact, (4) easy dormancy break, and (5) survival of drought.

Plant competition also could be divided according to the zone where it occurs. In this classification, it can be divide the competition into two levels: above and belowground. Several studies have provided evidence that in arid environments the belowground competition is more important than aboveground[(62)].

Harris and Wilson[(61)] suggested that in areas where the season of favorable moisture coincides with the season of low temperature, the ability of seedlings to continue root growth at low temperatures can be a deciding factor in the outcome of competition between species. They also studied the effect of soil moisture during the seedling establishment of forage cool-season grasses at low temperatures, concluding the existence of differences in root adventitious growth where the *Bromus tectorum* and *Taeniatherum asperwerum* were more successful than seedlings of *Agropyron spicatum*.

Invasive species have shown be more efficient in the seedling establishment than native species. It was reported[(63)] that invasive species germinates faster than native species, getting an advantage in the competition for light, space, and moisture. As mentioned, more studies are necessary to know how to occur the interaction between plants in the seedling stage in native grasses. It is important to mention that the first step in land reclamation is to eliminate the seed bank.

Seral stage

Several studies have indeed shown that annual plants have higher seedling growth rate[55,64] and higher allocation to reproductive structures[65,66] when compared to mid-seral and late successional plants. Newman and Moser[11] compared the seedling development among 12 grass species. They conclude that annual plants sprouted the first leaf faster than late seral species. Early seral species seem to allocate more energy to the shoot development than to the root system. Contrarily, mid and late seral seem to allocate more energy to root development. They conclude[56] that if the proportion of shoots is more than the roots in the seedling, higher are the risks of failure in the establishment caused by seedling acidification or an inefficient control in the water uptake.

Importance of the seminal and adventitious root pattern in the plant establishment (implications in the seedling survival)

As previous mentioned the establishment and survival of a plant are intrinsically correlated with emergence and extension of seminal and adventitious roots[56]. Other work[67] supports the idea that a plant cannot be considered established until it shows a plausive development of adventitious roots, which will allow extending down, catching moisture in deep levels of soil. To facilitate understanding the chronological sequence of morphological events that occur in a plant until the development of adventitious root the description mentioned by Whalley *et al*[68] was used. The author divides the growth of seedlings into three stages: the heterotrophic stage, a transitional stage, and the autotrophic stage.

The heterotrophic stage begins when the seed has contact with water being in this stage independent of other environmental factors, which means that the plant uses in its metabolism the energy reserves (starches) stored in the seed. After that phase, the plant still does not have a photosynthetic tissue. Hyder *et al*[17] affirm that plants easily surpass this stage in field conditions. Most of the researchers mistakenly consider the percent of seeds germinated as an indicator of seedling establishment. Hyder *et al*[17] affirm that less than eight percent of seeds germinated will reach the adult phase. The next transitional stage as the name suggests is a transition evolution to a photosynthetic phase. In this stage, the plants begin photosynthesis but still use energy reserves from the seeds for the expansion of root systems and the formation of new leaves. This phase can be divided into three sub-stages based on the development of the root system.

In the first step, the seedling shows only seminal roots. The seminal root system consists of one to five roots that developed from radicle and two pairs of lateral roots. Some investigators[21] affirm that seminal roots only are able to absorb water; while all nutrients necessary for the seedling come from the seeds reserves. The thick seminal roots has a limited capacity to absorb and translocate water in the plant. In the second step of this stage, the plants start to sprout the adventitious roots from the nodes in the crown. Some authors report this type of roots as true roots because they can absorb moisture and nutrients for the plant. In this step the seedlings show these two types of roots. Little is known about the interaction between these types of roots. The third stage is often marked by the weakening and death of seminal roots and the strength, extension and consolidation of adventitious roots as real roots. Haling *et al*[69] states that seminal roots persist only a short time after germination, their place being taken by adventitious roots. Some authors assert that the third seedling stage as the most important time in seedling establishment[40,70]. If the plant starts to lose its seminal roots before the adventitious roots reach a reasonable deep penetration in the soil profile, there is a high probability of failure in the establishment.

Due to a misunderstanding of the physiological bases of seedlings, most range managers associate the seedling establishment with the development of shoots. In American native grasses it was concluded that the stage of root development did not coincide with the stage of shoot development among species, which means that only a simple visual analysis cannot be considered a good indicator of success in the seedling emergence of American grasses[11]. Thus, it was affirmed[9] that to evaluate the success of the seedling establishment, variables such as size and age in the Klein grass seedling are also important and should be measured additionally the visual analysis.

In selected cultivars of big bluestem based on shoot weight and tiller number and they conclude that seedling tiller number and weight are not good indicators of seedling establishment success[71]. The development and extension of adventitious roots seem also to be associated with genetic factors. It was mentioned[72] that genetic variability appeared to correlate with adventitious root elongation in the blue grama, and that, in plants under the same edaphoclimatic conditions showed a broad diversity of development that could not be explained by environmental factors.

Conversely Chen *et al*[57] after investigated the root systems of several crops, conclude that the seminal root remains alive and active until the time of harvest, may is the reason of the success in the establishment of most cosmopolite crops. However some grass species seems to move in the same direction, Sánchez-Valdés *et al*[73] states that the seminal root of a ryegrass plants remains functional throughout the entire life of the plant. Same results were reported for other species[74].

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