Assessment of Performance inCereal Fodder Cropswith Relation to Seeding Rates and Cutting Stages

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ABSTRACT

Cereal fodder crops serve as indispensable sources of nutrition for livestock, contributing significantly to the efficiency and sustainability of animal production systems worldwide. Maximizing the productivity and quality of these crops requires careful management, with seed rates and cutting stages playing pivotal roles in determining crop performance. Seeding rates play a critical role in crop establishment and growth, with both low and high rates affecting plant competition and ultimately yield. Cutting stages, on the other hand, are pivotal in determining the quality and nutrient composition of the forage. Optimal cutting stages vary depending on the intended use, such as hay, silage, or grazing and can significantly influence digestibility and overall nutritional value. The assessment of cereal fodder crops is therefore pivotal for optimizing agricultural productivity and ensuring sustainable livestock feed production. Understanding the intricate relationship between seeding rates, cutting stages and crop performance is essential for sustainable agriculture and livestock production systems, contributing to improved resource efficiency and economic viability.

Keywords: Cereal fodder crops, Cutting stages, Livestock feed, Productivity, Quality, Seed rates

1. INTRODUCTION

Cereal fodder crops play a tremendous role in global agricultural sector, serving as essential components of livestock feed, thus contributing significantly to agricultural prosperity, productivity and sustainability. From 1993 to 2020, there is expected to be a twofold increase in the demand for livestock products, while meat and milk production in developing countries will see annual growth rates of 2.7% and 3.2%, respectively. [1]. The performance of cereal fodder crops, however, is intricately linked to various agronomic factors. Among the various factors influencing the performance of cereal fodder crops, seed rates and cutting stages have been identified as critical determinants of forage yield and quality. Initially, the focus of cereal crop improvement was primarily on enhancing grain yield, leading to the release of numerous dwarf, high-yielding varieties. However, in more recent times, there has been a growing acknowledgment of the importance of crop residues for livestock feed.

Consequently, there has been a shift in emphasis towards developing dual-purpose cultivars [2].

Among the diverse array of fodder crops, cereals such as barley, fodder maize, oats and wheat hold particular importance due to their adaptability, nutritional value and yield potential. These crops are widely used as feed for livestock, particularly for large ruminants such as cattle, sheep, and goats. The straw and stover of these crops are also important sources of livestock feed.

Wheat (*Triticum aestivum*) is the most important cereal crop in the world and it is widely used as a fodder crop. Wheat straw is an important fodder throughout the temperate and subtropical areas, and it is often grazed in winter in areas where this is possible. In parts of the Himalayan region, wheat is cut as fodder in times of scarcity, but it is less productive than oats. Wheat is also used as a silage crop, particularly in small-scale farming. Barley (*Hordeum vulgare*) is the second most important widely used fodder crop. Barley is important for malting as well as for human and livestock food. It is often used as a feed for pigs, poultry, and ruminants. Barley straw is also used as a fodder, particularly in small-scale farming. Oats (*Avena sativa, A. byzantina, and A. strigosa*) are a tall, annual cereal that is widely grown as a fodder in temperate and subtropical countries. Oats are often used as a feed for horses, cattle, and sheep. Oat straw is also used as a fodder, particularly in small-scale farming. Rye (*Secale cereale*) is an annual cereal that is widely used for winter pasture in North America and as a minor cereal in parts of Europe. It is adapted to poor soils and severe winters. It is often used as a feed for cattle, sheep and pigs. Rye straw is also used as a fodder, particularly in small-scale farming. Maize (*Zea mays*), also known as corn in North America, is a warm-season crop that is grown wherever summers are warm enough and rainfall or water supply is adequate. It is important as fodder, with the grain widely used in livestock feed, the stover fed to livestock, especially in the developing world, and the crop grown specifically as fodder on a large scale. Tropical maizes may reach 4 meters in height, while those in temperate and subtropical areas are mostly under 2 meters. Maize is the supreme silage crop, and it is often used as a feed for pigs, poultry, and ruminants. In addition to these common cereal fodder crops, there are also other plants that are specifically grown for fodder, such as alfalfa (*lucerne*), clover, grass and millet. They are often used as a source of protein and energy, and they are often used in combination with cereal crops to provide a balanced diet for livestock.

In recent years, the optimization of seed rates as well as cutting stages has garnered increasing attention from agronomists, researchers and farmers alike, driven by the imperative to enhance fodder crop yields while maintaining nutritional integrity. These interplay between seed rates and cutting stages represents a complex dynamic, influenced by factors such as climate conditions, crop genetics, soil fertility and management practices.

2. IMPACT OF SEED RATES ON CROP PERFORMANCE

Research has demonstrated that seed rates significantly affect the productivity and quality of cereal fodder crops. The significance of seeding rates in cereal fodder crop production lies in their direct impact on stand establishment, plant density and subsequent biomass accumulation. The productivity and quality of cereal fodder crops are influenced by a range of physiological processes, including tillering, biomass allocation and nutrient assimilation [3]. Seed rates directly affect plant population density with higher rates typically resulting in greater competition for resources and increased tillering capacity. Higher seed rates can result in increased biomass accumulation and fodder yield, particularly in the early stages of crop growth [4]. However, the relationship between seed rate and yield is not linear and there exists an optimal seeding density that maximizes yield without compromising quality [5]. Excessive seed rates may lead to overcrowding, reduced individual plant size and increased susceptibility to lodging. A study found that fodder-based intercropping systems significantly affected the quality of fodder [6]. It revealed that intercropping cereals with legumes improved the protein concentration of the fodder, making it more nutritious for livestock. Similarly, maturity of the crops also affected the production efficiency, nutritive value and in-situ nutrients digestibility of three cereal fodders [7]. The study revealed that cereal fodders harvested at maturity had a higher crude protein (CP) level than those harvested at earlier stages. Excessive seeding rates may lead to intra-specific competition for resources, reducing individual plant size, tiller number and decrease yield by increasing disease pressure, insects, and lodging [8]. Conversely, low seed rates may result in sparse stands, inefficient resource utilization and ultimately yield [9]. Therefore, optimal seeding rates must strike a balance between achieving an adequate plant population to maximize light interception and resource utilization while avoiding excessive competition among plants, which can lead to lodging, disease susceptibility, and reduced overall productivity. Moreover, seeding rates exert profound effects on crop architecture, influencing factors such as tillering capacity, stem diameter, and biomass allocation, all of which have implications for fodder quality and digestibility.

3. INFLUENCE OF CUTTING STAGES ON CROP YIELD AND QUALITY

Cutting stage is an important factor in determining the quality and yield of cereal crops used for hay, silage, or grazing. It represent a critical management decision point in cereal fodder crop production, determining the timing of harvest relative to crop development and physiological maturity. The choice of cutting stage profoundly influences not only biomass yield but also nutritional composition, digestibility and regrowth potential. It influences the balance between vegetative growth and reproductive development, with early cutting promoting leafy biomass accumulation and late cutting favoring seed or grain production [10]. The timing and frequency of cutting events profoundly impact the yield and quality of cereal fodder crops. For hay, the crop should be cut at the milky stage, before the stems become woody, and then tied into sheaves and dried in the field. This stage is typically reached when the kernels on the seed head begin to thicken and if squeezed, a white, milky substance is visible. For silage, the crop should be cut at the boot to early head stage, when the seed head swells in the flag leaf sheath but has not yet emerged. This stage allows for optimal fermentation and preservation of nutrients. For grazing, plants can be grazed when 8-10 inches tall during rapid spring growth. Encouraging spring tillering with nitrogen applications at dormancy break/spring green-up can enhance forage quality and yield. Early cutting stages promote the accumulation of leafy biomass, which is often higher in protein content and digestibility compared to mature stems. It may prioritize forage quality, capturing peak levels of protein, digestible fiber and energy at the expense of total biomass yield. However, frequent cutting at early stages may impede plant regrowth and reduce overall biomass production over time [11]. On the contrary, late cutting stages, while maximizing total biomass yield, may result in lower forage quality due to increased lignification and reduced nutrient content [12]. Balancing the trade-offs between yield and quality requires careful consideration of factors such as crop growth stage, weather conditions and livestock nutritional requirements [13]. Hay quality evaluation of summer grass and legume forage monocultures and mixtures grown under irrigated conditions significantly affected the nutritive value of the fodder [14]. The study found that cereal fodders harvested at the vegetative stage had a higher CP level than those harvested at the reproductive stage. Similarly, researchers found that the feed value of alfalfa (*Medicago sativa* L.) harvested at different maturity stages significantly affected the nutritive value of the fodder. The study found that alfalfa harvested at the early flowering stage had a higher CP level than those harvested at the late flowering stage [15]. Integrated management approaches that incorporate both seed rates and cutting stages can help optimize forage production while maintaining nutritional value and feed efficiency. A study revealed that cutting stage significantly affected the yield of cereal fodder crops. The study revealed that cutting at the early vegetative stage resulted in higher forage yield and CP level [16]. However, the study also found that cutting at the early vegetative stage decreased the NDF level, making the fodder less fibrous. Another studyreported that cutting stage significantly affected the nutritive value of cereal fodder crops. Cutting at the early vegetative stage resulted in higher CP and IVDDM levels [17]. However, the study also found that cutting at the early vegetative stage decreased the NDF level, making the fodder less fibrous.

The cutting stage therefore significantly impacts the nutritional value of cereal fodder crops. The nutritional quality of fodder primarily depends on the species composition and its developmental stage, both of which are influenced by climatic conditions impacting mineral content, regrowth capacity, sward structure and botanical makeup [18]. Harvesting at the correct stage is thus crucial to ensure optimal nutrient content and digestibility. For instance, cutting cereal crops at the boot to early head stage for silage or at the milky stage for hay can help preserve essential nutrients and maintain high-quality forage. Therefore, proper timing of the cutting stage is essential to maximize the nutritional quality of cereal fodder crops for livestock feed.

Despite the recognized importance of seeding rates and cutting stages in cereal fodder crop production, a comprehensive understanding of their interactive effects and optimal management strategies remains elusive. Existing literature offers valuable insights into the individual impacts of seeding rates and cutting stages on fodder crop performance, yet a synthesis of this knowledge is warranted to inform evidence-based management decisions and drive innovation in fodder crop production systems. By understanding the physiological basis of seed rates and cutting stages, growers can make informed decisions to optimize crop growth and development while maximizing forage yield and quality.

4. INTERACTION EFFECTS AND MANAGEMENT STRATEGIES

The interactions between seed rates and cutting stages complicate crop management decisions, requiring growers to adopt integrated approaches that consider both practices simultaneously. Research has shown that the combined effects of seed rates and cutting stages on crop performance are often non-linear and context-dependent. For example, higher seed rates may mitigate the negative effects of early cutting by increasing tiller density and compensatory growth potential [19]. Conversely, late cutting stages may offset the yield benefits of high seed rates by limiting regrowth capacity and reducing forage quality [20]. Therefore, growers must tailor their management strategies to specific cropping conditions, taking into account factors such as soil type, climate variability and livestock feeding requirements [21]. Integrated crop management practices that optimize seeding density, cutting timing, and nutrient management can help maximize forage production and quality while minimizing environmental impacts and resource inputs.

5. INTERCROPPING AND CEREAL FODDER CROP PERFORMANCE

Intercropping that involves growing two or more crops simultaneously on the same piece of land has been found to improve the yield and nutritional quality of forage crops. A study registered that legume-cereal intercropping significantly improved forage yield, quality and degradability [22]. Intercropping improved the CP level of the fodder, making it more nutritious for livestock. Similarly, cereal-legume forages had higher productivity and profitability than monoculture cropping systems [23]. The study reveals that intercropping improved the soil nutrient status, leading to higher yields and better quality fodder. Intercropping fodder maize crops with legumes also significantly improved the yield, CP level, soil nutrient status and quality of the fodder [24].

6. EFFECT OF HARVEST TIMING ON THE NUTRITIONAL QUALITY OF CEREAL FODDER CROPS

The timing of cutting cereal fodder crops significantly affects their nutritional value. Research indicates that later cutting stages can improve digestibility and digestible energy intake, resulting in a higher yield of forage per acre. This is because the plant has more time to accumulate nutrients, particularly starch, which can offset the contribution of neutral detergent fibre (NDF) towards energy supply. Harvesting at the late milk to early dough stage for barley and the late milk stage for oats can improve digestible nutrient yield without sorting, ruminal fermentation, ruminal digestibility, or total-tract digestibility. Total-tract starch digestibility tends to increase with advancing maturity, from 60% digestible at the late-milk stage up to 80% at the mature stage for oats. However, the increase in forage yield is likely to vary from year to year depending on growing conditions. The chemical analysis of whole-crop forage samples revealed more feed-quality advantages than drawbacks as the crops advanced. There were significant differences in nutrient composition from the late-milk stage to the hard-dough stage, but very little change from then to maturity. Overall, organic matter and non-fibre carbohydrates (total starch and sugar except those tied up in cell walls) increased as the crops advanced. However, there were some disadvantages to later cutting stages, such as decreased calcium and crude protein (CP) content. Although phosphorus decreased, this is not viewed as a disadvantage because phosphorus content in cereals is on the high side relative to calcium. The forages were put to the true test for feed quality in a feeding trial coupled with a metabolism study involving ruminally cannulated animals. The results showed that animals fed rations containing cereal forages cut at the hard-dough and mature stages had lower rumen pH levels than those fed rations containing cereal forages cut at earlier stages. This indicates that the additional starch in the later-cut forages is digestible. Harvesting cereal fodder crops at the hard-dough stage has the potential to improve digestible nutrient yield without sorting, ruminal fermentation, ruminal digestibility or total-tract digestibility. However, there are some cautions to consider, such as a potential for grain loss due to shelling in the field, the need to provide calcium and protein to balance the diet, and the chance that feeding cereal forages cut at later stages of maturity could cause acidosis. Susceptibility to acidosis varies among animals, and producers should consult with their nutritionist to make appropriate ration adjustments.

7. RECOMMENDED CUTTING STAGES OF VARIOUS CEREALS

The recommended cutting stages for cereal fodder crops vary depending on the crop type and the desired outcome. For barley, it is recommended to harvest at the whole crop stage for silage, while oats or triticale provide better leaf yield if crops are cut at the green chop stage. *Triticale* can be harvested at either the green chop or whole crop stage, with the whole crop stage maximizing yield and carbohydrate content and the green chop stage maximizing protein content at the expense of yield and carbohydrate. Harvesting between these stages is not advised as it fails to produce optimum yield or quality. For oat crops, harvesting for silage (GCCS) should only be done at the booting stage, as this species is not ideal for whole crop cereal silage. Barley is recommended to be harvested at the whole crop stage, with either oats or triticale providing better leaf yield if crops are cut at the green chop stage. Harvesting at the flag leaf or boot to early ear emergence stage for cereal crops requires the crop to be wilted to reach the desired DM content before harvesting, particularly for cereal and legume mixtures. Mowing with a roller type mower conditioner is recommended to crimp or crack the stems, which will encourage wilting and increase the rate of wilting by 20 to 40% compared to mowing only. Tyned type mower conditioners will also increase the rate of wilting through mainly an abrading (bruising) action on the stems.

8. FACTORS TO CONSIDER WHEN DETERMINING SEEDING RATE FOR CEREAL FODDER CROPS

When determining the seeding rate for cereal fodder crops, several factors need to be considered to optimize forage production and quality. These factors include:

8.1. Planting Date: Following recommended planting dates is crucial for maximizing forage potential. Early planting enhances total forage production, while late planting can limit hay or silage production potential.

8.2. Seeding Rates: Seeding rates for small grain cereals should be adjusted based on the intended use. For fall grazing, seeding rates should be 25 to 50% higher than normal to provide forage earlier in the fall. Thicker plantings can reduce stem size and make curing or ensiling easier.

8.3. Fertilization: Adequate fertilizer amounts, particularly nitrogen, are essential for maximizing forage production. Small grain cereals respond well to nitrogen, and increased rates are recommended when grown for pasture. Soil testing and following fertilizer recommendations are crucial for optimal growth.

8.4. Species Composition: The choice of cereal species and potential mixtures, such as cereal-pea mixtures, can impact forage quality and yield. Adding peas to cereals can improve forage quality, but it may not necessarily increase yields.

8.5. Plant Health Concerns: Consideration should be given to potential plant health concerns, such as nitrate poisoning, especially when selecting species for hay or silage production.Cereal fodder crops play a crucial role in providing essential nutrients for livestock feed, but their production faces numerous challenges, including climate change, water scarcity, soil.quality issues, pests, diseases, and weeds

9. CHALLENGES OF GROWING FODDER CROPS

Cereal fodder crops play a crucial role in providing essential nutrients for livestock feed, but their production faces numerous challenges, including climate change, water scarcity, soil quality issues, pests, diseases, and weeds

9.1. Climate Change: Changing climatic conditions, like droughts and heatwaves, pose a significant threat to cereal fodder crop yields and quality. Collaborative research and engagement with producers are essential to develop resilient crop varieties and agronomic practices.

9.2. Water Scarcity: In semi-arid regions, water scarcity limits cereal fodder crop production. Traditional methods like fallow years help, but innovative solutions such as drought-tolerant varieties and efficient irrigation systems are needed.

9.3. Soil Quality: Poor soil quality, characterized by low fertility and structure, affects crop productivity. Implementing soil management practices like organic fertilization and crop rotation is crucial for improving soil quality.

9.4. Pests and Diseases: Pests and diseases can devastate cereal fodder crops, leading to yield losses. Integrated pest management strategies, including resistant varieties and biological control methods, are necessary to minimize their impact.

9.5. Weeds: Weeds compete with crops for resources and reduce yields. Effective weed management practices like herbicide use and crop rotation are essential for maintaining crop productivity.

10. FUTURE PROSPECTS

. The assessment of cereal fodder crop performance concerning seeding rates and cutting stages presents promising avenues for future research and practical application. Further exploration could focus on:

10.1. Optimization of Seeding Rates: Investigating the optimal seeding rates tailored to specific cereal fodder crops and environmental conditions could enhance yield and quality. Employing advanced techniques such as precision agriculture and remote sensing may provide insights into achieving maximum productivity while conserving resources.

10.2. Fine-Tuning Cutting Stages: Delving deeper into the effects of different cutting stages on crop yield, nutrient content, and regrowth potential can refine management practices. Long-term studies assessing the sustainability of various cutting regimes on soil health and biodiversity are imperative for informed decision-making.

10.3. Climate Resilience: With changing climatic patterns, there's a need to evaluate how cereal fodder crops respond to varying temperature and precipitation regimes. Research into cultivar selection, agronomic practices, and alternative cropping systems can aid in mitigating climate-induced challenges and ensuring stable fodder production.

10.4. Integrated Management Approaches: Exploring integrated crop management strategies incorporating seeding rates, cutting stages, irrigation, fertilization, and pest control can optimize productivity while minimizing environmental impact. Interdisciplinary collaborations between agronomists, ecologists, geneticists, and economists can foster holistic solutions for sustainable fodder production.

10.5. Technology Adoption: Embracing innovative technologies such as precision agriculture, drone-based monitoring, and data analytics can revolutionize cereal fodder crop management. Integrating digital tools for real-time decision support systems and farm-level automation holds immense potential for enhancing efficiency and profitability.

10.6. Economic Viability and Market Demand: Assessing the economic feasibility of different seeding rates and cutting regimes in relation to market demand for fodder products is crucial for farmer adoption. Conducting market surveys and value chain analyses can identify opportunities for niche markets and value-added products.

10.7. Extension and Outreach: Facilitating knowledge dissemination and capacity building among farmers through extension services, training programs, and demonstration plots can promote the adoption of best management practices. Engaging stakeholders including farmers, policymakers, and industry representatives in participatory research initiatives can ensure relevance and uptake of research findings.

11. CONCLUSION

Optimizing cereal fodder crop management requires a holistic approach that integrates seed rates and cutting stages to maximize productivity and quality. By understanding the physiological basis of these management practices and their interactions, growers can make informed decisions to enhance forage production efficiency and sustainability. Future research should focus on developing innovative management strategies that address the complexities of modern livestock production systems while promoting environmental stewardship and resilience to climate change. Through collaborative efforts among researchers, practitioners, and policymakers, the optimization of cereal fodder crop management holds great potential for advancing sustainable agriculture and ensuring food security for future generations.

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