

Review Article

Exploring the effects of nutrient management on growth attributes, fodder qualities and soil properties of fodder Oats (*Avena sativa*): An overview

Abstract

Livestock is a significant economic contributor to a country and is essential to the production of milk, eggs, and meats for the country's expanding population. Farmers may plant a variety of fodder and feed to get good advantages all year long. Oats can be an excellent option for a fodder crop when there is a limited water supply. Among cereals, oats (*Avena sativa L.*) is a significant, nutrient-dense forage crop. North, Central, and Western regions of the nation oats are been cultivated. Around 0.5 Mha of the country's land is used for oat farming. As a wholesome grain and fodder, oats (*Avena sativa L.*) constitute a significant livestock feed source all over the world. Since a century ago, oat (*Avena sativa L.*) has been grown, but its production potential has not yet been fully realised in order to address the winter feed shortage. The oats can be intercropped alongside other fodder legumes such lucerne, pea, and berseem. Therefore, in order to maximise productivity per unit area, it is vital to consider the fodder species with higher fodder production and good quality as compatibility for mix cropping.

Keywords: Cereals, Fodder, Oats, , livestock and nutrient management

Introduction

The backbone of the Indian economy is agriculture and 54.6 percent of Indians still rely on it. (Anonymous, 2018). In the production of food grains, India self-sufficient. The country's present food grain production successfully satisfies the rising need of the continually expanding human population. The demand for fodder is at an all-time became high at the same time that the demand for food grains is rising. Additionally, the lack of fodder has become worse as a result of the recent rapid decline in pasture areas and grassland as well as the poor management of the existent pastures (Jat *et al.*, 2015). The primary source of livestock wealth and the foundation of the livestock industry are forages. The lack of grazing resources and green forages in the nation has caused livestock to consistently suffer from malnutrition, resulting in a sub-optimal level of production potential in comparison to other nations. The double crops could be cultivated such that green fodder for livestock and grain for consumption for humans and can be obtained from

the same crop for meeting the need of food grains from an expanding population and reduce the pressure on pastureland. In the year 2025, there may be a 64.9 percent shortage of green fodder and a 24.9 percent scarcity of dry fodder. In these conditions, improving the forage resources is the only option to close the supply-demand gap for fodder. Oats are an essential crop for winter feed and forages. It is a potential fodder crop because of its superior habit of growth, greater regenerative capability, and great fodder quality (Kumar and Singh, 2018). Oat (*Avena sativa* L.) is the annual plant Gramineae family. It is a very important feed crop and it is sown at the time of October & November. North-Western India also has oat farms that are rain-fed. Owing to the germination, tillering, booting, and heading stages of growth oat needs a cold environment. It often reaches heights of 155–165 cm, barely over wheat, and has long, succulent leaves. It fits into the dairy production programme because of its great palatability and cooling effect on animals (Anonymous, 2007). When collected at the 50% flowering stage, its fodder comprises crude protein is 10-11.5 %, neutral detergent fibre (NDF) is 55-63 %, 30-32 % acid detergent fibre (ACD), 22.0% to 23.5 % cellulose, and 17-20 % hemicellulose. As straw, hay, or silage, oat is also used. Oats are successfully produced in the hilly regions and plains of the nation because they need a long cool season for growth. The oat plant thrives in moderate climates. Its best growth occurs in regions with winter temperatures between 15 and 25 °C. Although it can endure some frost, hot and dry circumstances have a negative impact on its fodder quality and yield (Anonymous, 2012). Oats are cultivated both in tropical and temperate climates due to its characteristics. Oats are a significant winter fodder crop in India's northern and northwest due to its great growth characteristics, fast regrowth, and value as a source of dietary protein. In 2 to 3 cuttings, it produces succulent and palatable fodder (Bhilare and Joshi, 2007). Hence, Oats can be successfully grown as multiple-cut fodder. In winter oats are sown as a dual-purpose crop that may be harvested for both grain and temporary winter grazing (Hussain et al., 2002). Owing to an increase in the number of cattle and agricultural rotation practises that provide limited room for the growth of green forages, the scarcity of fodder crops is getting worse by the day. As a result, it essential to improve yield of high-quality feed, and in the irrigated areas of northern India as oat is one of the significant Rabi fodder crops. (1975, Singh et al.) Oats provide a number of benefits, including early availability of fodder, nutritious fodder, high yield potential, palatability, a strong capacity for regeneration, and a greater dry matter content. It is an excellent source of calories, protein, iron, phosphorus, and vitamin B. Additionally, as a hay oat can be

used and silage for feeding animals when there is a shortage of available fodder. Oats can be a cost-effective source of dietary protein because, when managed for cutting from December to April, they produce luscious and extremely tasty fodder (Kumar, 2012). Oats have a lot of potential to increase the quality of the country's available fodder, which will directly enhance the health and milk capacity of milch animals. Additionally, feeding milch animals' high-quality fodder will significantly raise the quality of their milk, which will ultimately enhance human health. In addition, oats are consumed by humans because they yield high-quality grains that may be used to make flooring, oat meal, cookies, and other products with a variety of uses. Hence, we are presenting some of the effects of nutrient management on different properties of oat based cropping system.



Fig 1: Growth of fodder Oats under different nutrient management

A husbandry practise known as intercropping involves growing many crops on the same plot of land at the same time (Vandermeer, 1989). Intercropping is a cultural practise that increases yield stability because it is unlikely that weather variability would affect every crop equally in a mixed cropping system. With complementing canopies and roots systems, crops with diverse growth patterns may have varied environmental needs. They can sometimes make better use of water, nutrients, and light than monocultures can. There is evidence that using intercrops as animal feed can increase overall productivity. In various regions of the world, intercropping has been done in a number of methods based on the producer's need, such as hay, silage, grazing, or green chop.

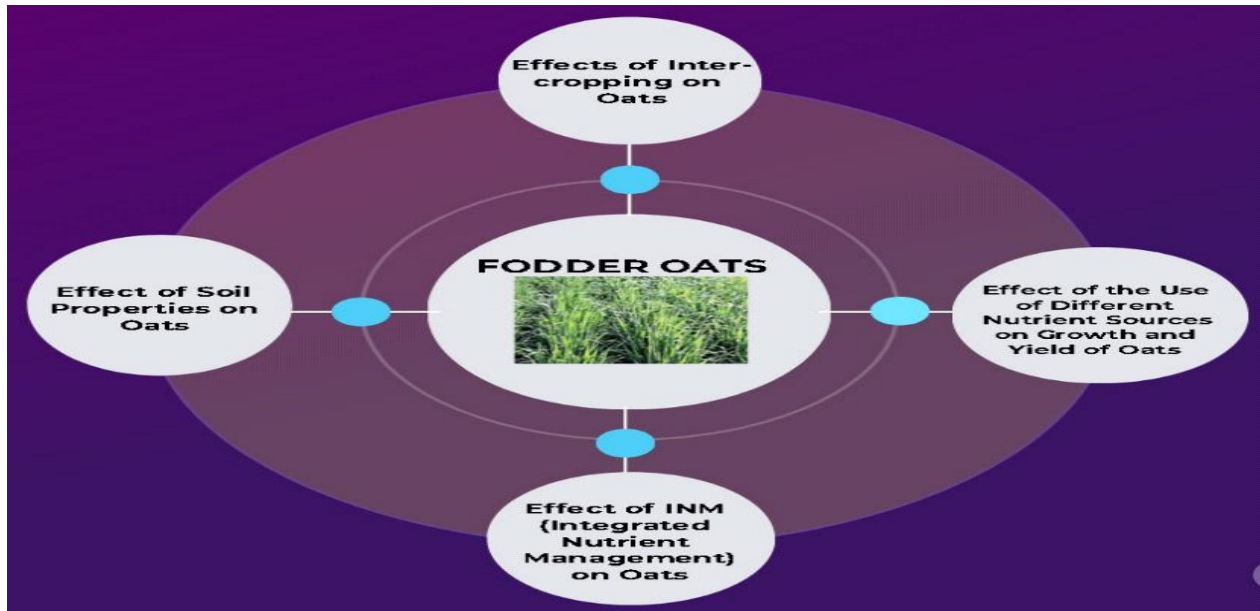


Fig 2: Analysing the effect of different components on oat cropping system

- Effect on growth and yield attributes of oat due simultaneous cultivation of crops in same field and time

One of the key justifications for implementing such a system is to deliver a balanced feed supply for diverse livestock production needs. Intercropping with legumes can increase the yield of forage oats. Legumes such as alfalfa, clover or astragalus can bind atmospheric nitrogen and make it available to oats, improving their growth and yield (Gao *et al.*, 2020). Intercropping can help suppress weeds and reduce the need for herbicides. Indeed, companion crops can compete with weeds for resources, reducing their growth and spread (Liu *et al.*, 2016). The impact of intercropping on forage oats depends on the specific crop used and the management practices used. For example, if legumes are intercropped too aggressively, they can outcompete oats for nutrients and sunlight, reducing overall crop yields. Additionally, some legumes can produce allelopathic compounds that inhibit the growth of oats (Yan *et al.*, 2020). Proper selection and careful management of intercropping partners can maximize the benefits of intercropping while minimizing its negative impacts. Intercropping has proven to be a sustainable agricultural practice that increases productivity, reduces the incidence of pests and diseases, and improves soil fertility. Forage intercropping oats with legumes such as clover, astragalus and peas has been

extensively studied and shown to increase dry matter yield, protein content and the digestibility of forage grasses. Indeed, legumes can fix nitrogen in the atmosphere and improve the nitrogen status of the soil, thus improving the quality of pastures. Furthermore, intercropping with legumes can also promote biodiversity and reduce the occurrence of pests and diseases. As example, a work by Moragues *et al.*, (2018) reveal that intercropping forage oats with legumes increased pasture yield and protein content. Forage intercropping oats with Brassica species such as radishes, turnips and kale has also been studied and shown to increase yield and protein content of pastures. For example, a study by Cazzato *et al.*, (2017) found that intercropping radish and forage oats increased pasture yield and protein content, but also resulted in high nitrate levels. Forage intercropping oats with cereals such as wheat, barley and rye also has advantages. Cereals can supplement nutritional requirements and provide additional biomass, but result in lower protein content in the diet. A work conducted by Thakur *et al.*, (2019) found that intercropping forage oats with wheat increased crude protein content and yield of dry matter of fodder grasses. Oat can be used as fodder and mixed with a legume like a pea, berseem, or vetch (*Vicia sp*, Ross *et al.*, 2004; Undersander, 2003; Johnston *et al.*, 1999). Legumes and oats work well together to control weeds, prevent disease, and use more of the available resources by enhancing the crop's nutritional value in comparison to oats alone. (Undersander, 2003). Intercropping is a long-established technique that is frequently employed in low-input cropping systems around the world. (Anil *et al.*, 1998). As a result of external inputs use, particularly fertilisers, crop production in the 20th century transitioned from being primarily labor-intensive to being more optimised. (Crews & Peoples, 2004). Because of the increased awareness of environmental deterioration brought on by the intensive use of non-renewable resources, intercropping systems have gained popularity in industrialised nations (Fujita *et al.*, 1992). Several important benefits of intercropping systems, particularly cereals with legumes, include improved soil conservation (Anil *et al.*, 1998), a higher total yield and better land use efficiency (Dhima *et al.*, 2007), yield stability of the cropping system, better utilisation of light, water, and nutrients (Javanmard *et al.*, 2009), and improved pest and weed management (Banik *et al.*, 2006; Vasilakoglou *et al.*) The traditional method of growing annual crops such as peas and grasses such as oat in mixed is known as intercropping. Oats are a staple in the production of hay, pasture, and silage for livestock and are frequently farmed either by themselves or in combination with other grains (McKenzie & Spomer, 1999). There have been several findings

indicating that combining pea and oat yields boosted hay production (Robinson, 1960; Mitchell, 1983). The amount and quality of the hay are both improved by inter-cropping oats crop with fodder legumes such as vetch (Khalili *et al.*, 1992 & Umunna *et al.*, 1995). According to various studies, crossbred cows (*Bos taurus* *Bos indicus*) produced more milk when oat-vetch hay was supplemented with a high or concentrates fodder legume hay (Khalili *et al.*, 1992; Khalili *et al.*, 1994 & Mpairwe *et al.*, 2003). Akhtar *et al.* ,(2020) examined the effects of nanourea on the growth and yield of oat plants under drought stress conditions. The researchers found that nanourea improved the growth and yield of the plants, as well as their water use efficiency, compared to traditional urea fertilizer. They suggested that the improved performance of the oat plants could be due to the smaller particle size and more uniform distribution of nutrients in the nanourea. They looked at the effects of nanourea on intercropping of maize and cowpea. The researchers found that nanourea improved the growth and yield of both crops, and also increased the nitrogen use efficiency of the intercropping system.

Table 1 : Cropping pattern and percentage of crude protein

Cropping Pattern	Crude Protein (%)	Reference
Oats + Pea	13.88%	Amonge, P., Thakuria, k., & Saikia, j. intercropping of oilseed crops with oat fodder in rice fallows under rainfed condition.
Oats + Linseed	6.66%	
Oats + Toria	6.60%	
Oats + Lucerne	16.72%	NinamaSD, Shroff JC and Mehta PV (2020) Effect of different row ratios on yield and quality of oat (<i>Avena sativa</i> L.) and Lucerne (<i>Medicago sativa</i> L.) intercropping.

- **Effect of Combined Nutrient application on growth and yield attributes of oats (*Avena sativa*)**



Fig 3: Integrated Nutrient Management approaches

Combined use of organic and inorganic nutrients is essential for increasing fertility of soil, which can reduce the need for expensive and ecologically hazardous fertilisers for the current and following crops (Saikat Biswas *et al.*). In addition to supplying organic materials, organic sources such as poultry manure (PM), farm yard manure (FYM), compost, green manuring, and among others, also improve the soil fertility condition (Chang *et al.*, 1991 & Brady 1996; Chung *et al.*, 2000 & Keupper and Gegner 2004). Manures provide the necessary nutrients and also enhance the chemical and physical characteristics of the soil (Sharpley *et al.*, 2004). Chemical fertilisers are an essential component of contemporary crop production techniques. Chemical fertilisers cannot be completely replaced by other methods (NFDC 1997). The combination of inorganic and organic nutrient sources provided necessary nutrients and also had some beneficial interactions with chemical fertilisers to boost their effectiveness and so lowers environmental hazard (Ahmad *et al.*, 1996). Singh *et al.*, (2017) performed to evaluate the effect of nutrient management on yield, quality and nutrient uptake of oats in northern India. They found that combining the organic and inorganic sources significantly increased the yield, quality and nutrient absorption of oats compared to the control treatment. Jha *et al.*, (2015) performed an experiment to investigate the effect of INM on fodder yield, soil quality and fertility of an oat farming system in India. They found that use of combined nutrients significantly increased soil fertility parameters as well as yield and forage quality compared to control treatments. Kaur and Singh (2015) evaluated the effect of INM on quality, yield and nutrient uptake in oats they found that integration of nutrients significantly increased oat yield and nutrient uptake compared to the control treatment, while quality parameters were not significantly affected. Fathi *et al.*, (2019)

conducted a study to investigate the effects of different organic and inorganic treatments on oat yield, quality and nutrient uptake. They found that the combination of chemical fertilizer and organic fertilizers gave oats the highest yield, quality and nutrient uptake compared to other combined treatments. Choudhary and Parihar (2016) conducted a study in India to assess the effect of integrated nutrient management on oat yield, quality and nutrient uptake. They found that INM significantly increased oat yield and nutrient uptake compared to the control treatment, but there were no change quality parameters significantly. After rice was cultivated in kharif using 50% RDF combined with FYM at 10t/ha, Roy *et al.*, (2009) observed significant nutrient uptakes of oat grown in residual soil fertility. Sharma *et al.*, (2004) applied 50% RDF along with vermicompost and FYM each at 2.5t/ha to achieve the highest level of economic viability for oat cultivation, which was followed closely by application of 50% RDF along with vermicompost at 2.5t/ha. By applying 80 or 120kg N/ha along with vermicompost @ 10t/ha and inoculation of seed through Azotobacter and compared to the control, Devi *et al.*, (2014) obtained higher gross and net returns from oat cultivation. With 100% RDF, vermicompost at 5 t/ha, seed inoculation with biofertilizer (azotobacter) at 2 kg/ha, and seed inoculation, Rawat and Agrawal (2010) also achieved good economic return from oat field. According to Deva *et al.*, (2014), 100% RDF application together with seed inoculation using PSB and Azotobacter produced the maximum net realisation and BC ratio in oat production. Patel *et al.*, (2010) found that oat cultivation had a good net financial return when 120 kg of nitrogen per hectare was applied and seeds were inoculated with Azotobacter. The application of 150kg N ha⁻¹ along with inoculation of seed through Azotobacter and PSB. Sharma & Verma (2005) obtained maximum net returns and returns per rupee spent; however, the energy productivity and energy ratio were obtained with the usage of 100 kg N ha⁻¹, seed inoculation through Azotobacter, and sheep manure at 10 t/ha. Sharma (2009) discovered that oat had high economic viability, energy responsiveness, energy productivity, and energy ratio with the usage of 100 kg N ha⁻¹ along with inoculation of seed through Azotobacter and PSB. Salem *et al.*, (2018) investigated the effect of using combined sources of nano urea and compost on the growth and yield of maize. The study found that the combined use of nano urea and compost significantly increased maize growth and yield compared to using either input alone. Gholami *et al.*, (2021) found the effect of using combined sources of nano urea and biochar on the yield and quality of maize. The study found that the

combined use of nano urea and biochar significantly increased maize yield and quality compared to using either input alone.

➤ **Effect on soil properties due to cultivation of Oats (*Avena sativa*)**

An essential component of Indian soil is the management of nutrients. The organic substrate for plant growth is called soil, and it directly affects the quantity and quality of crops. A natural habitat for plant growth that includes minerals, organic matter, and living things makes up soil (Buckman and Brady., 1968) which differ in their biological, morphological and physiochemical characteristics (Nongrum et al., 2021). Saini *et al.*, (2019) found that soil pH had a significant effect on forage oat growth and yield his results shown that a soil pH of 6.5 gives the highest yields. Salim *et al.*, (2016) obtained a significant positive correlation between soil organic matter and yield. Studies have shown that yields are highest when the soil organic matter content is 2.5%. also, Golchin *et al.*, (2021) reported the effect of soil moisture on the yield and growth of forage oats he found that yields are highest at 80% soil moisture. Singh *et al.*, (2020) investigated the effect of soil nutrients on the growth and yield of forage oats. The study found that the additions of nitrogen(N), phosphorus(P) and potassium(K) significantly increased the forage yield of oats. The soil quality of Punjab and its potential as a marker for various land uses were the focus of Vashisht *et al.*, (2020) research. The scientist observed that the pH of the soil's ranges from neutral to alkaline. Between 6.5 and 9.4 is the pH range. Maninder *et al.*, (2020) studied the level of soil fertility in a few villages in the Punjabi province of Hoshiarpur, according to the study, pH indicates that nature is neutral to severely alkaline. The range of the EC in soil samples is 0.16 to 0.67 mmhos/cm. Yadav *et al.*, (2016) conducted research on the fertility of the Punjab soils as the soil depth is increased, the organic carbon content in the top soil layers decreases. The optimum soil pH for oats is between 6.0 and 6.5, with pH values below 5.5 or above 7.0 causing reduced growth and yield due to a deficiency in nutrients and aluminum toxicity (Chen *et al.*, 2019; Li *et al.*, 2018; Zhao *et al.*, 2017). Proper application of nitrogen(N), phosphorus (P) and potassium(K) fertilizers is very crucial for optimum oat yield and growth. The optimal rates of N, P and K were found to be 90, 45 and 90 kg/ha respectively (Ahmad *et al.*, 2007, 2016; Gul *et al.*, 2018; Zhou *et al.*, 2019). Soil compaction can limit root growth and reduce nutrient uptake, reducing oat growth and yield. Research has shown that soil compaction can be mitigated through the adoption of cover crops reduced tillage, and proper management of

soil organic matter (Caviglia *et al.*, 2017; Gresta *et al.*, 2016; Zhao *et al.*, 2016). Adequate soil moisture is very important for optimum oat growth and yield, studies have shown that water stress can significantly reduce oat growth and yield, and the optimum soil moisture content for oat growth is 60% to 80% of the water capacity of the field (Asgari *et al.*, 2018; Caviglia *et al.*, 2018; Li *et al.*, 2020). Oats prefer cooler temperatures and high temperatures (>25°C) during the vegetative phase led to reduced growth and yield, studies have shown that the optimum soil temperature range for oat growth is between 15°C and 20°C (Chen *et al.*, 2007). Oats grown in loamy soils produced significantly more than those grown in sandy loam soils, according to an Indian study. This is probably because loamy soils have a greater capacity to hold water and are more nutrient-rich (Mishra *et al.*, 2020). An additional study done in India discovered that using farmyard manure to increase soil organic matter greatly increased oats' grain yield and nutrient content, with the greatest yield being attained at a rate of 10 tons/ha of manure (Sarkar *et al.*, 2020). According to a research done in India, oats produce more grain when phosphorus fertiliser is applied, with the ideal rate being 60 kg/ha of phosphorus (Singh *et al.*, 2020). Soil pH levels between 6.0 and 7.0 are ideal for oat growth and yield, with pH levels below 5.5 or above 8.0 leading to decreased growth and yield due to nutrient deficiencies and aluminium toxicity (Babu *et al.*, 2020). Maintaining soil moisture at 80% of field capacity during the growing season significantly increased yield and nutrient content of oats compared to oats grown in the field. water stress conditions (Acharya *et al.*, 2020). Saberali *et al.*, (2018) reported that the application of nano urea to fodder oats increased soil nitrogen and phosphorus content, as well as soil organic matter content. Jafari *et al.*, (2019) found that the use of nano urea improved soil properties such as soil organic matter and available phosphorus in oats compared to conventional urea. Hasanuzzaman and Fujita (2020) reported that the use of nano urea increased soil organic matter and improved soil fertility in oats.

➤ **Effect of B:C ratios by the effect of oat (*Avena sativa*) cropping system**

According to Jayanthi *et al.*, (2002), the usage of combination sources of inorganic and organic fertilisers resulted in a larger no. of tillers per square metre in the oats crop. When vermicompost was combined with inorganic nutrient sources, Puneeth Raj and Vyakaranahal (2014) showed that the oat variety "OS6" produced the greatest results in terms of growth characteristics. Chellamuthu *et al.*, (2000) found that applying biofertilizer together with 75% of the required

nitrogen fertiliser increased plant height compared to applying 100% NP alone. The treatment that received no fertiliser showed a minimum dry weight of 2.97 g per tiller (control). The highest leaf area plant-1 (128 cm²) was obtained by applying inorganic fertiliser NP at a rate of 150::60 kg ha⁻¹ compared to the other treatments according to Chaudhary & Khade (1991) and Randhawa *et al.*, (1994). Adding vermicompost and farmyard manure dramatically raised oat plants' height, number of tillers, and dry matter output (Kumar *et al.*, 2021). Using compost enhanced oat plant height, leaf area, and chlorophyll content (Mohammadi *et al.*, 2020). The usage of nitrogen fertiliser can increase the growth characteristics of fodder oats, leading to higher yields and better quality feed. Fodder oats have been reported to exhibit good growth qualities, including high tillering ability, early vigour, and quick growth rate (Molla *et al.*, 2020). Adding nitrogen fertiliser to the soil greatly raised the output of oats feed. The application of 120 kg ha⁻¹ of urea resulted the maximum yield. (Vivek *et al.*, 2020).

Table 2 : List of treatments use for gross and net returns

Treatment	Gross returns (Rs ha⁻¹)	Net returns (Rs ha⁻¹)	B C Ratio	Reference
Oats (sole)	84282	49719	2.43	NinamaSD, Shroff JC and Mehta PV(2020)Effect of different row ratios on yield and quality of oat (<i>Avena sativa</i> L.) and Lucerne (<i>Medicago sativa</i> L.) intercropping
Oat+Lucerne	81692	45860	2.28	NinamaSD, Shroff JC and Mehta PV (2020) Effect of different row ratios on yield and quality of oat (<i>Avena sativa</i> L.) and Lucerne (<i>Medicago sativa</i> L.) intercropping
Oat+Berseem	102760	69790	1.47	Muskan Porval (2021) Effect of nano Zinc and Oat+Berseem intercropping on fodder yield and Quality.

Conclusion

In conclusion, nutrient management practices have a significant impact on the growth attributes, fodder qualities, and soil properties of fodder oats (*Avena sativa*). Proper nutrient management, including the application of fertilizers and organic amendments, can lead to increased plant growth, higher yields, and improved fodder quality. In particular, the application of nitrogen fertilizer has been shown to increase plant height, leaf area, and biomass production in fodder oats. However, excessive fertilizer application can have negative effects on soil properties, including soil organic matter content and pH. Therefore, it is important to balance nutrient management practices with the need to maintain soil health and fertility. Overall, this study highlights the importance of proper nutrient management in the cultivation of fodder oats, and the potential benefits that can be gained through sustainable and balanced fertilization practices.

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