Evaluation of Chrysopogon Aciculatus (Ritz.) Trin. Seed for Sod Production in Ghana: An Assessment of Growth Performance and Post Harvest Quality

ABSTRACT

This study examined the growth and post-harvest quality of sod produced from C. aciculatus seed, a popular turfgrass in Ghana. Although viable and readily available, C. aciculatus seeds are not commonly used, and its sod quality characteristics are unknown. The experiment was conducted at the College of Agriculture Education, AAMUSTED, Mampong campus, using a 3 x 3 factorial experiment in a Randomized Complete Block Design with three replications, using a wooden frame system. The treatment factors were Fertilizer (10 t/ha chicken manure, 450 kg ha-1 Foliar fertilizer, and No fertilizer) and base netting (Rubber fiber net, Jute mat, and No net). Results showed that chicken manure with no base net and chicken manure with rubber fiber net interactions provided the earliest days to seedling emergence. Chicken manure and foliar-fertilized sods had significantly higher Clipping fresh and dry weights. Higher sod tensile strength, lasting, and handling quality were recorded with chicken manure and rubber fiber net interaction as the best performance in all instances. In conclusion, C. aciculatus seed can be used to produce high-quality sod, and it is recommended for commercial sod production in Ghana. Chicken manure and rubber fiber net interactions are the best treatments for achieving optimal results in C. aciculatus sod production.

Keywords: Chrysopogon aciculatus, seed, sod lasting quality, sod tensile strength, sod handling quality, base netting, and growth performance.

1. Introduction

Sod is a mat-like piece of lawn consisting of grass with soil bound to its roots that enables it to continue growing seamlessly when transplanted to another plot [1]. Sodding is advantageous as it can be used quickly to prevent wastage [2] of material and can be established year-round with the best turfgrass varieties from producers. Sod lends itself especially to the total installation or repair of smaller areas, producing almost instant results in areas such as football and soccer pitches as well as lawns [3].

One popular turfgrass used in many lawns and sports fields is *Chrysopogon aciculatus (Retz.) Trin.*, commonly called Love grass in Ghana. It is a warm-season grass that belongs to the family Poaceae, subfamily Panicoideae, and tribe Andropogoneae [4]. Love grass has a distinct sod-forming growth habit and has been extensively propagated as turf in Africa and other tropical regions, including Asia. It is classified in many advanced countries as a noxious weed due to its quick-spreading growth and invasive seed-forming inflorescence [5]. Consequently, it has been largely ignored in the commercial sod production industry in most countries where sod is produced.

Growing a good turf mostly requires the addition of organic or inorganic fertilizers to improve soil nutrient levels. Organic fertilizers are preferred due to their positive impact on soil physicochemical properties, lower adverse impact on the environment, and availability. Chicken manure is a type of organic fertilizer that is high in nitrogen and phosphorus compared to other bulky organic manure and is relatively affordable and accessible in Ghana. In turf production, foliar fertilizers are also regularly used, and they can be essential when the soil conditions are not optimal or conducive for roots to take up nutrients [6].

An approach in sod production to provide sod strength and shorten harvesting times is the use of base netting. Using netting and soil amendments have resulted in drastic improvements in the production duration of up to 2 to 3 weeks after planting and 9 months after planting, respectively [7, 8, and 9], when compared to the regular conventional methods requiring up to 2 years after planting.

Love grass is usually planted with sprigs on topsoil, which is sometimes mixed with composted manure [10], The seeds of love grass are also very prominent, easily accessible, and mostly viable but are usually mown together with the leaf clippings and discarded, completely disregarding their potential as good propagation material if saved. Its creeping or spreading growth style, resistance to heat, drought, and trampling could also make it ideal for sod production as it easily spreads and forms a mat-like growth over soil.

Although there have been many studies on the medicinal and phytotoxic properties of C. aciculatus, there is a lack of literature on its qualities as a turfgrass, especially from its seed. [11] concluded that, seeds of *C. aciculatus*, are nitrophilous as they exhibited a remarkable enhancement in germination when treated with 0.5% KNO_3 solution. In a corresponding study, [12] studied the effects of nitrogen fertility on the performance of “Port Harcourt grass”, *Chrysopogon aciculatus* (Retz.) Trin. using tillers to determine the optimum N rate for the turf quality features. The study concluded that fertility rates influence turf quality characteristics differently. To bridge this knowledge gap, the current study, assessed the growth and post-harvest quality of *C. aciculatus* sod produced from saved seed with a recommended rate of chicken manure and foliar fertilizer over different base netting materials.

2. Method

2.1 Study area

From September 2020 to March 2021, the experiment was conducted at the research site of the College of Agriculture Education, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development, Mampong Campus. The study area is situated within the savannah transitional zone of Ghana, with an altitude of approximately 457 meters above sea level [13]. The area experiences an annual rainfall ranging between 1094 mm and 1200 mm, with mean daily and monthly temperatures of 30.50C and 32.00C, respectively [14]. The soil type in the study area is the Bediese series, which is sandy loam, well-drained, and has a thin layer of organic matter. The soil is classified as Ochrosol formed from Voltaian sandstone, and its pH ranges from 6.0 to 6.5 [15]

2.2 Layout and Experimental and Set-up

The experiment was conducted in a wooden frame system, which was used as plots for the sod. Each wooden frame had internal dimensions of 90 cm x 60 cm and a depth of 5 cm. To prevent termite damage, the frames were treated with a 2% Dursban® 4E solution. A 250 microns industrial black polythene sheet was used as a first layer to cover the entire experimental area and as a second layer to serve as a lining and protection for the wooden frames. Extra polythene sheets were cut into 120 cm x 80 cm pieces and placed in each frame. The soil was sieved to remove all debris and treated with 2% Acetastar, then covered with a transparent polythene sheet for two weeks before use. The study used two base netting materials, namely rubber fiber net and jute mats. The rubber fiber net was purchased in rolls and cut into 60 cm x 90 cm pieces, and the jute mats were purchased as sacks and cut into 60 cm x 90 cm mats for the experiments. River sand was used to fill out the spaces between the wooden frames for the experiment (Plate 1).

Plate1: A; a view of the study site and experimental layout. B; harvesting of sod.

2.3 Experimental Design and Procedure

The experiment was laid out in a 3 x 3 factorial randomized complete block design with three replications. The factors were Fertilizer (10 t/ha Chicken manure (CM)), 450 kg ha-1 Foliar fertilizer(F), and No Fertilizer(C) and base netting (rubber fiber net, jute, and no net). A spacing of 30 cm between plots and 60 cm between blocks was used. Watering was done twice daily (morning and evening). Weeding was done every three weeks until the grass had fully covered the plots. Seeds of love grass were harvested by hand from a lawn and stored in brown paper bags for two weeks at room temperature in the laboratory. Seeds were sown at 7 grams per plot. Decomposed Chicken manure and Harvestmore® Foliar fertilizer were obtained from the research farm of CAGRIC, AAMUSTED, and Chemico Ghana LTD in Asante Mampong, respectively and applied at recommended rates for the study. The decomposed Chicken manure was applied two weeks before sowing at a rate of 10 tons ha^{-1} [16] and subsequently applied at 8-week intervals. Harvestmore® Foliar fertilizer was applied on the day of planting and subsequently applied at weekly intervals at a rate of 450 kg ha-1.

2.4 Data Collection

The sod was harvested six months after planting, which was 184 days after planting (DAP), by carefully lifting it from the wooden frame (Plate 1B). Data was then collected on days to seedling emergence, tiller length, clipping yield (both fresh and dry weight), weed load, chlorophyll content index (CCI), sod tensile strength, sod lasting quality, and sod handling quality.

The days to seedling emergence were estimated by recording the number of days until the emergence of the seedlings was observed. Tiller length was measured by randomly selecting nine tillers from each frame, three in the middle and three at both ends of a frame. Clipping yield was measured by weighing the fresh clippings and the dry weight after drying the clippings in an oven in the lab at 60°C for 48 hours. Weed load was measured by hand-picking weeds from each frame and weighing them on an electronic scale after bagging. The Chlorophyll content index (CCI) of the grass was estimated using the AtLeaf® Chlorophyll meter, following the method outlined by [12]. The tensile strength of each sod sample was measured using a modified adaptation of the method used by [17] with a Sod Tensile Strength (STS) measuring device, and the STS readings were converted into newtons (N). Sod lasting quality was assessed by observing the color change of the harvested sod over a period of three weeks without being transplanted or watered, rated on a scale of 1-9, and sod handling quality (SHQ) was rated on a scale of 1 to 5, in accordance with the method used by [17]. All visual assessments were conducted by a trained panel of five assessors, and ratings were consistent with the assessment protocols of the National Turfgrass Evaluation Programme (NTEP, USA).

2.5 Data Analysis

After collecting the data, analysis of variance was performed using Statistix® version 10. The Tukey's Honestly Significant Difference (HSD) test was used to compare the treatment means at a 5% level of probability to determine the statistical significance of any differences between treatment groups.

3. Results

3.1 Days to Seedling Emergence.

The data analysis revealed that the interaction between fertilizer and base netting materials had a significant ($p<0.05$) effect on the days to seedling emergence. Specifically, chicken manure with no net (CM-Nonet) and chicken manure with rubber fiber net (CM-Net) interactions resulted in the earliest days to emergence at 14 days, while CM-Jute had the longest number of days to emergence at 16 days, which was significantly different from the other chicken manure treated plots. In contrast, foliar fertilizer treated plots had similar days to emergence of 16 and 16.33, while control plots emerged the latest at 17 days after sowing.

Table 1: Days to the emergence of *Chrysopogon aciculatus* seed as influenced by fertilizer and base netting treatment.

Treatments	Chicken manure	Foliar	Control	Mean
Rubber net	14.33^{bc}	16.00^{abc}	17.00^{a}	15.78^{a}
Jute mat	16.00^{abc}	16.00^{abc}	17.00^{a}	16.33^{a}
No net	14.00^{c}	16.33^{ab}	17.00^{a}	15.78^{a}
Mean	14.78^{b}	16.11^{a}	17.00^{a}	

HSD: Fertilizer (0.91), Base Netting (0.9), Interaction (2.18). Means with the same superscripted letter(s) are not significantly different at $p\leq 0.05$.

3.2 Tiller length

There were significant differences in tiller length at 60 DAP among the treatments. The highest (7.65cm) tiller length was recorded in the F-NET treatment while the lowest (3.91cm) was recorded in the C-JUTE treatment. The chicken manure treatments (CM-Net, CM-Nonet, and CM-Jute) recorded similar tiller lengths, which were higher than the control treatment. These results suggest that the application of foliar fertilizer and chicken manure can promote the growth and development of lovegrass (Table 2).

3.3 Weed load

The results in Table 2 show that Control with no net interaction recorded the least weed load of 17.67 g/m^2 at 90 DAP, which was significantly lower ($p<0.05$) than F-Jute which recorded the highest weed load of 105.67 g/m^2. The weed load recorded in each treatment reflects the ability of that treatment to help the lovegrass suppress weed growth. The use of foliar fertilizer and Chicken Manure in some treatments enhanced nutrient availability for weed growth, resulting in higher means in those plots. This implies that nutrient management is an important factor to consider when managing weed growth.

3.4 Chlorophyll content index (CCI)

CM-Net recorded the highest mean chlorophyll content index (CCI) of 40.28, indicating a healthy growth of the grass (Table 2). Conversely, control or unfertilized interaction plots recorded lower CCI means of 30.74, 30.78, and 31.06 for C-Net, C-Nonet, and C-Jute, respectively.

Table 2: Tiller length, weed load, and CCI of *Chrysopogon aciculatus* sod established on plots amended with fertilizers and base netting materials.

Treatments	**Tiller length(cm) 60DAP**	**Weed load(g/m^2) 90DAP**	**CCI 90DAP**
CM-Net	6.51^{ab}	56.67^{bc}	40.28^{a}
CM-Nonet	5.75^{ab}	52.1^{bc}	37.96^{a}
CM-Jute	6.31^{ab}	45^{bc}	36.53^{a}
F-Net	7.65^{a}	49^{bc}	40.29^{a}
F-Nonet	6.17^{ab}	64.67^{ab}	34.97^{ab}
F-Jute	4.07^{b}	105.67^{a}	30.43^{b}
C-Net	3.91^{b}	40.67^{bc}	30.74^{b}
C-Nonet	5.38^{ab}	17.67^{c}	30.78^{b}
C-Jute	4.55^{ab}	47^{bc}	31.06^{b}
HSD	*3.24*	*45.01*	*5.39*
P-values	*0.5591*	*0.0107*	*0.0210*

Means with the same superscripted letter(s) are not significantly different at $p \leq 0.05$.

3.5 Clipping Yield

The results show that there were significant differences in clipping fresh weight (CFW) and clipping dry weight (CDW) between the treatments for both the first and second mowing. For the first mowing, F-Net had the highest CFW of 10.33g/m^2, while C-Net and C-Nonet had the lowest of 3.33g/m^2. However, after drying, CM-Net had the highest CDW of 5.33g/m^2, and C-Jute had the lowest CDW of 0.33g/m^2 for the first mowing. For the second mowing, F-Nonet had the highest CFW of 22.33g/m^2, while CM-Nonet had the lowest of 5.33g/m^2. Similarly, CM-Net had the highest CDW of 4.33g/m^2, which was significantly different from C-Jute that had the lowest of 0.33g/m^2.

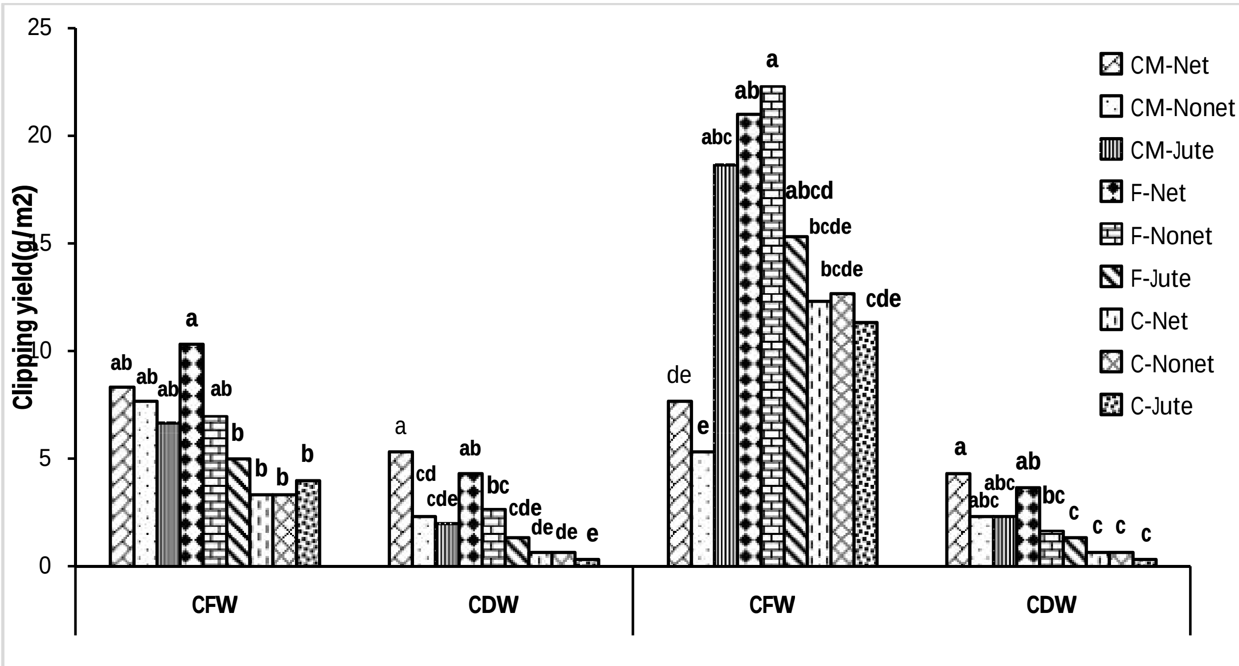

Fig 1: Clipping fresh and dry weights from *C. aciculatus* sod established from saved seed with different fertilizers and base netting materials.

3.6 Sod Tensile strength (STS) and Sod handling quality (SHQ)

According to Table 3, the combination of chicken manure and rubber fibre net yielded the highest tensile strength value of 774.99 N, which was significantly ($p<0.05$) greater than F-Jute's 42.48N. Conversely, the sod for foliar fertilizer and jute mat interaction was weak and easily torn by the STS device. F-Net and C-Net followed CM-Net sod with STS values of 415.26N and 315.11N, respectively. These values were strong and considered acceptable for commercial sod production. There were significant ($p<0.05$) differences between treatments for sod handling quality (SHQ). Chicken manure and net interaction recorded the highest rating of 4.17 out of 5 which was significantly ($p\leq0.05$) higher than C-Jute with the least mean value (1.00). Other netted sods (F-Net and C-Net) obtained acceptable SHQ ratings above 3.0 as well (Table 3).

Table 3: Sod tensile strength and sod handling quality of *Chrysopogon aciculatus* sod established on plots amended with fertilizers and base netting materials.

Treatment	Sod Handling Quality (SHQ)	Sod Tensile Strength (STS) (N)
CM-Net	4.17[a]	774.99[a]
CM-Jute	2.67[bc]	163.53[bc]
CM-Nonet	2.17[cd]	147.15[bc]
F-Net	3.67[ab]	415.26[b]
F-Jute	1.17[de]	42.48[c]
F-Nonet	1.50[de]	127.53[bc]
C-Net	3.33[ab]	340.11[bc]
C-Jute	1.00[e]	68.67[c]
C-Nonet	1.83[cde]	130.77[bc]
HSD	*1.01*	*336.97*
P-values	*0.0298*	*0.0465*

Means with the same letters(s) under the same column are not significantly different ($P \leq 0.05$)

3.7 Sod Lasting Quality (SLQ)

There were significant differences between treatment means after the first week of observation. The highest rating of 8.0 was observed in CM-Net and F-Nonet, while the least rating of 6.33 was observed in F-Jute. However, all sods were still in an acceptable state as they had a good green color.At week 2, CM-Net produced the highest SLQ rating of 5.67, which was significantly higher than the SLQ for CM-Jute and F-Jute, which recorded the least rating of 3.0. However, after week 3, all ratings for SLQ were unacceptable.

Table 4: Effect of fertilizer and netting on lasting quality of sod

TREATMENT	WEEK 1	WEEK 2	WEEK 3
CM-NET	8.00^{a}	5.67^{a}	4.00^{a}
F-NONET	8.00^{a}	5.00^{ab}	1.33^{b}
F-NET	7.67^{ab}	3.67^{bc}	2.67^{ab}
C-NET	7.67^{ab}	4.33^{abc}	1.67^{b}
C-NONET	7.67^{ab}	4.33^{abc}	1.33^{b}
CM-JUTE	7.00^{abc}	3.00^{c}	1.33^{b}
CM-NONET	7.00^{abc}	4.67^{abc}	2.67^{ab}
C-JUTE	6.67^{bc}	4.33$_{abc}$	1.33^{b}
F-JUTE	6.33^{c}	3.00^{c}	2.00^{b}
HSD	*1.33*	*1.73*	*1.74*
P-values	*0.0053*	*0.0034*	*0.0010*

Means with the same letters(s) under the same column are not significantly different ($P \leq 0.05$)

4. Discussion

4.1 Days to Seedling Emergence

The base netting materials alone did not significantly($p>0.05$) affect the days to emergence, while the main effect of fertilizer had a significant difference. These results suggest that the combination of chicken manure with rubber fiber net and no net had the most favorable impact on seedling emergence, and the use of foliar fertilizer also promoted early emergence. As reported by [18], the application of chicken manure to the soil in sufficient amounts was found to have a positive impact on the emergence of onion seeds, as well as on the vegetative growth of the plants. This observation is consistent with the findings of [19], who studied the effect of chicken manure on the growth of Sorghum bicolor. In addition, [20] also reported that the rate and availability of chicken manure throughout the growing season was responsible for the rapid emergence and vegetative growth of the plant.

4.2 Tiller Length

The improvement in plant growth observed in the study can be attributed to the increased availability of nutrients in the soil and through the leaves. The primary macronutrients, such as nitrogen, phosphorus, and potassium, are essential for plant growth and are typically found in higher concentrations in foliar fertilizers. As stated by [21], the presence of these nutrients promotes the formation of plant metabolites that contribute to the growth and development of the plant tissue.

Foliar fertilizers are absorbed through the stomata of the leaves and transported down through the plant, which enhances vegetative growth and development. This mechanism could explain the superior performance of the F-Net treatment compared to other treatments. Additionally, foliar fertilization has been found to be more efficient than soil fertilization for both macro and micronutrients in various soil types, according to [22] Overall, the use of foliar fertilizers can lead to improved plant growth and yield, making it a valuable addition to traditional soil fertilization methods.

4.3 Weed Load

The exceptionally high weed load in the F-Jute treatment could be attributed to the jute mat initially suppressing the growth of the lovegrass as it may have absorbed and retained soil moisture in those plots, leading to water stress and more space for weeds to grow. After the jute mat had decomposed, it released nutrients back into the soil, resulting in a double supply of nutrients for both the grass and weeds from the foliar fertilizer and the decomposed jute mat. A review by [23] highlighted the role of soil fertility in weed management, noting that high levels of soil fertility can promote weed growth and that nutrient imbalances can also favor certain weed species, highlighting the importance of considering the timing and duration of treatments and their impacts on nutrient availability.

4.4 Chlorophyll Content Index (CCI)

Generally, CCI values below 35 for *C. aciculatus* indicates poor plant health [12]. Organic and inorganic fertilizers have been found to increase chlorophyll content in plant leaves ,because it has major nitrogen (N) content [24] . Studies have also shown a positive correlation between chlorophyll content, carotenoid content, and N levels in plants [25]; [26]. Higher chlorophyll content is an indicator of healthy plant growth as it is responsible for harvesting light energy, stabilizing membranes, and energy transduction [27]. In addition, [12] demonstrated the possibility of using CCI readings obtained from ATLeaf chlorophyll meter to determine chlorophyll concentrations in plants, by establishing a correlation between chlorophyll a and b concentrations and CCI in their study.

4.5 Clipping Yield

Clipping yield is an important measure of grass productivity and quality, and it is commonly used to assess the effectiveness of different fertilization strategies.

The results suggest that the increased nutrient level provided by chicken manure and foliar fertilizers may have contributed to the higher clipping yield observed in the fertilized sods. This is consistent with findings from previous studies such as [28],which reported higher fresh weights in plants treated with organic fertilizers. In addition, the CDW of the fertilized sods was also higher, indicating greater biomass production. This is in line with the findings of [29] who found that the role of nitrogen in enhancing meristematic activity and cell division can lead to increased vegetative growth and higher biomass yield in plants.

It is interesting to note that while CM-Net treated sod had lower CFW values, it produced a greater CDW than foliar treated sods, indicating higher biomass. This suggests that different types of fertilizers may have varying effects on the growth and yield of grass. Overall, the results suggest that the application of organic and inorganic fertilizers can improve clipping yield and biomass production in grass, which can be attributed to the increased nutrient availability provided by these fertilizers.

4.6 Sod Tensile Strength and Sod Handling Quality

The treatments exhibited significant ($p<0.05$) differences in sod handling quality (SHQ). The combination of chicken manure and net achieved the highest rating of 4.17 out of 5, which was significantly ($p\leq0.05$) greater than the lowest mean value of 1.00 for C-Jute. Other netted sods (F-Net and C-Net) received SHQ ratings above 3.0, which were also considered acceptable.

Rubber fiber netted sods exhibited superior tensile strength and handling quality, likely attributable to the strong elastic and helical nature of the net that provided robust support for the grass roots, leading to the formation of a strong sod. These findings align with [30] research, which found that fertilizer treatments generally supplied sufficient nutrients for the grass's vegetative growth, while the net's helical structure provided anchorage for smooth root establishment and improved the sod's tensile strength. Additionally, the interaction of chicken manure, foliar fertilizer, and control with rubber fiber net produced sods with higher handling quality values, suitable for turf production, as similarly rated by [31]. Furthermore, chicken manure and foliar fertilizer with net interactions enhanced the sod handling quality performance of love grass seeds, consistent with [32] findings.

4.7 Sod Lasting Quality

Sod Lasting Quality is defined as the ability of harvested sod to maintain acceptable value under shade without transplanting or watering. Sod was visually acceptable or up to two weeks following its extraction. The superior lasting quality performance of Chicken manure-treated sods was likely attributable to increased chlorophyll content within the leaves resulting from adequate nitrogen availability. This factor, in turn, affects the green color of the sod and delays the onset of wilting or yellowing. Moreover, A higher moisture content present in the foliar and chicken manure sods at the time of harvest may have facilitated the preservation of the sod's freshness over a more extended period. [33] reported that N fertilization led to higher sod quality after storage, while K fertilization improved sod storage characteristics. The application of organic fertilizer likely contributed to the improved organic matter content and possible enhancement of the soil's water-holding capacity as evidenced by the presence of soil still attached to the roots of all sods post-harvest. Similarly, [34] identified several key factors that affect the storage life of Kentucky bluegrass sod. Specifically, they found that the type of soil, timing of harvest, and storage temperature were all critical factors that influenced the longevity of stored sod.

5. Conclusions

This research aimed to evaluate the growth and post-harvest quality of lovegrass (C. aciculatus) seed for sod production. The study found that the average time for seedling emergence was 16 days, with the addition of chicken manure resulting in a shorter emergence time of 14 days. Furthermore, the use of rubber fiber netting with chicken manure and foliar fertilizer led to a significant improvement in various parameters, such as tiller length, CCI, and clipping biomass, indicating better growth performance. Additionally, the application of rubber fiber netting with foliar fertilizer and chicken manure enhanced the sod's tensile strength, lasting capacity, and handling quality, meeting commercial standards set by the National Turfgrass Evaluation Program (NTEP, USA). On the other hand, using jute mat as a netting material did not have any significant effect on the sod strength, as it decomposed quickly before harvest time. Overall, the findings suggest that C. aciculatus seed can be utilized for commercial sod production, and the addition of chicken manure and foliar fertilizer, coupled with rubber fiber netting, can significantly improve its growth and post-harvest handling qualities.

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