

Original Research Article

Optimizing Seed Rate and Integrated Weed Management for Enhanced Fibre Yield in Tossa Jute (*Corchorus olitorius* L.) under Diverse Agro-Climatic Conditions of Bangladesh

Abstract

The study was conducted during the 2023 cropping season at two locations—Jute Research Regional Station (JRRS), Kishoreganj, and Jute Research Sub-Station (JRSS), Jashore—to identify the optimum seed rate and suitable weed management practices for Tossa jute (*Corchorus olitorius* L.). The experiment followed a randomized complete block design (RCBD) with three replications and six treatment combinations involving variable seed rates (3.0–5.5 kg ha⁻¹) with or without filler materials and herbicidal integrations. Results revealed significant variation among treatments for plant population, growth parameters, and yield components. The combination of 4.5 kg ha⁻¹ live seed + 1.5 kg ha⁻¹ filler (ash) + Pendimethalin 33% EC + one hand weeding at 25 DAS produced the highest fibre and stick yields (3.50–3.60 t ha⁻¹ and 6.64–6.72 t ha⁻¹, respectively) across both locations. The lowest yields were recorded under the lowest seed rate (3.0 kg ha⁻¹) due to inadequate stand establishment. Moderate seed density, coupled with integrated weed management, effectively balanced plant competition, enhanced morphological traits, and increased overall productivity. These findings suggest that using 4.5 kg ha⁻¹ seed along with Pendimethalin and one hand weeding is the most efficient and sustainable practice for achieving higher jute yield under varying agro-ecological conditions of Bangladesh.

1. Introduction

Jute (*Corchorus olitorius* L.) is one of the most important natural bast fibre crops cultivated extensively in Bangladesh, India, and parts of Southeast Asia. It serves as a cash crop for millions of smallholder and marginal farmers who depend on its cultivation for both income and employment (Kumari *et al.*, 2018; Akter *et al.*, 2020). As an eco-friendly and biodegradable fibre, jute is highly valued for its use in producing textiles, composites, paper, packaging, ropes, mats, and geotextiles, contributing significantly to the country's export economy (Majumder *et al.*, 2020; Mukul *et al.*, 2021). The crop also plays a crucial environmental role in improving soil organic matter, sequestering atmospheric carbon, and reducing dependency on synthetic materials (Islam & Ali, 2017; Anonymous, 2022).

Despite its potential, the productivity of jute in Bangladesh has not increased substantially over the years due to the continued use of traditional production systems. Broadcasting is still the

dominant sowing method used by most farmers, resulting in uneven plant stands, high plant density, and severe intra-specific competition (Mandal & Mukherjee, 2018; Ghorai, 2015). High-density sowing (HDS) not only limits nutrient uptake but also increases weeding and thinning requirements, thus raising labour costs and reducing economic efficiency (Singh *et al.*, 2015; Bhuiyan *et al.*, 2018). Conversely, low-density sowing (LDS) using line sowing promotes uniform plant growth, better resource utilization, and improved air and light penetration, which can significantly enhance fibre yield and quality (Kumar *et al.*, 2015; Karimi *et al.*, 2021).

Weed competition is one of the major biotic constraints in jute production, causing heavy yield losses when not managed effectively (Hossain *et al.*, 2023; Singh, Bhagwan & Prakash, 2015). Manual weeding is effective but labour-intensive and time-consuming, particularly under current conditions of rural labour shortages (Swanton *et al.*, 2015; Chakraborty *et al.*, 2020). Chemical weed management using selective herbicides like Pretilachlor and Pendimethalin has shown efficiency in controlling early-season weeds in jute and other fibre crops when used judiciously (Mahajan & Chauhan, 2013; Hossain *et al.*, 2024; Mahbub & Bhuiyan, 2021). Integrating herbicidal application with manual weeding and optimized sowing density forms a sustainable weed control approach, improving yield stability and profitability (Abbas *et al.*, 2018; Jena *et al.*, 2017; Mandal & Mukherjee, 2018).

Previous studies have mainly emphasized weed management or varietal improvement, whereas limited attention has been given to the synergistic effects of seed rate optimization and integrated weed management under different agro-ecological conditions (Korres & Norsworthy, 2015; Susa *et al.*, 2018; Zimdahl & Basinger, 2024). Regional variations in soil type, rainfall, and temperature may alter the crop's response to different sowing densities and herbicide combinations (Ngomuo *et al.*, 2017; Sarkar & Gawande, 2016; Mukherjee, 2013). Therefore, the present study was undertaken at two contrasting agro-climatic regions—Kishoreganj and Jashore—to determine the optimum seed rate and integrated weed management practices for maximizing fibre yield and yield attributes of *Corchorus olitorius* L. under field conditions. The results are expected to provide region-specific recommendations for sustainable jute cultivation in Bangladesh.

2. Materials and Methods

2.1 Experimental Sites and Design

The field experiments were conducted during the 2023 growing season at two locations: the Jute Research Regional Station (JRRS), Kishoreganj, and the Jute Research Sub-Station (JRSS), Jashore. Both sites represent distinct agro-ecological conditions of Bangladesh—Kishoreganj, characterized by a humid subtropical climate with heavier alluvial soils, while Jashore experiences moderately dry conditions with loamy soils and slightly higher temperature regimes (Anonymous, 2022; Islam & Ali, 2017). These contrasting environments were selected to evaluate the stability and adaptability of treatments under varied climatic and edaphic conditions.

At both sites, the experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications (Gomez & Gomez, 1984). The test variety was BJRI Tossa Pat-8 (Robi-1), a widely cultivated high-yielding tossa jute variety (Mukul *et al.*, 2021; Mandal & Mukherjee, 2018). Each experimental plot measured 4.0 m × 2.5 m, with 1.0 m spacing between plots and 1.5 m between replications to ensure proper isolation and uniform growth (Kumar *et al.*, 2015; Ghorai, 2015).

2.2 Treatments and Crop Management

Six seed rate and weed management combinations were evaluated as treatments:

3.0 kg ha⁻¹ live seed + 3.0 kg ha⁻¹ filler (ash) + hand weeding at 25 DAS

3.5 kg ha⁻¹ live seed + 2.5 kg ha⁻¹ filler + Pretilachlor 50 EC + one hand weeding at 25 DAS

4.0 kg ha⁻¹ live seed + 2.0 kg ha⁻¹ filler + one hand weeding at 25 DAS

4.5 kg ha⁻¹ live seed + 1.5 kg ha⁻¹ filler + Pendimethalin 33% EC + one hand weeding at 25 DAS

5.0 kg ha⁻¹ live seed + 1.0 kg ha⁻¹ filler + one hand weeding at 25 DAS

5.5 kg ha⁻¹ live seed + no filler + one hand weeding at 25 DAS

The fillers used were ash to improve uniform seed distribution and reduce clumping during sowing. Herbicides Pretilachlor 50 EC @ 0.9 kg ha⁻¹ and Pendimethalin 33% EC @ 2.5 L ha⁻¹ were applied 48 hours after sowing for effective weed suppression following integrated weed management principles (Hossain *et al.*, 2024; Abbas *et al.*, 2018; Mahajan & Chauhan, 2013). The recommended basal dose of fertilizers was Urea, TSP, and MOP at 65:50:30 kg ha⁻¹, respectively, and topdressing with urea was done at 25 and 45 DAS, followed by irrigation (Singh *et al.*, 2015; Mandal & Mukherjee, 2018). Standard agronomic practices including gap filling, pest management, and weed control were maintained as per BJRI guidelines (Kumar *et al.*, 2015; Ghorai, 2015).

2.3 Data Recording and Statistical Analysis

Observations were recorded at harvest for plant population, plant height, base diameter, fibre yield, and stick yield (Hossain *et al.*, 2023; Mukul *et al.*, 2021). Retting was performed using standard water-retting techniques, and dry fibre yield was expressed in tonnes per hectare. The collected data from both locations were subjected to combined analysis of variance (ANOVA) using the R software (version 4.3.2) employing the Analysis of Design of Experiments for Biological Research package (Swanton *et al.*, 2015; Zimdahl & Basinger, 2024). Mean differences among treatments were tested using the Least Significant Difference (LSD) method at the 5% level of significance (Gomez & Gomez, 1984). Comparative interpretation between locations was made to assess the consistency and stability of treatment responses (Korres & Norsworthy, 2015; Hossain *et al.*, 2024).

3. Results and Discussion

a) For Jute Research Regional Station, Kishoreganj

3.1 Plant Population

Significant variation ($P < 0.05$) was observed among the treatments for plant population per square meter (Table 1). The highest plant population (42.00 m⁻²) was recorded from T₆ (5.5 kg ha⁻¹ live

seed + one hand weeding), while the lowest (19.00 m^{-2}) occurred in T₁ (3.0 kg ha^{-1} live seed + 3.0 kg ha^{-1} filler + hand weeding). The progressive increase in plant population with higher seeding rates was expected since greater seed density enhanced initial plant stand establishment (Karimi *et al.*, 2021). However, extremely dense stands are often associated with increased intra-specific competition and reduced plant vigor (Morsy & Tantawy, 2018). Similar findings were reported by Kumar *et al.* (2015) and Mandal & Mukherjee (2018), who demonstrated that excessive plant density in *C. olitorius* can restrict root expansion and resource uptake, ultimately lowering yield efficiency. This result confirms that moderate plant density (around 30 m^{-2}) is optimal for jute under line sowing conditions, consistent with the recommendations of Islam & Ali (2017).

3.2 Plant Height and Base Diameter

Plant height (PH) and base diameter (BD) differed significantly across treatments. The tallest plants (3.51 m) and the largest stem diameter (20.30 mm) were obtained from T₁, while the shortest plants (3.10 m) and the smallest diameter (14.75 mm) were observed in T₆. The inverse relationship between density and individual plant growth indicates that competition for sunlight, nutrients, and moisture increases with higher plant populations (Susha *et al.*, 2018; Charles *et al.*, 2019). Ghorai (2015) and Singh *et al.* (2015) also reported similar trends, where sparse sowing allowed better canopy development and thicker stems, improving fibre strength and retting efficiency. The reduction in diameter under dense sowing observed here supports the argument that balanced spacing ensures efficient utilization of growth resources, leading to superior plant morphology and higher fibre yield potential (Korres & Norsworthy, 2015).

3.3 Fibre Yield

Fibre yield (FY) was significantly influenced by the combined effect of seed rate and weed management. The treatment T₄ (4.5 kg ha^{-1} live seed + 1.5 kg ha^{-1} filler + Pendimethalin 33% EC + one hand weeding) produced the highest fibre yield (3.50 t ha^{-1}), followed by T₆ (3.37 t ha^{-1}) and T₅ (3.31 t ha^{-1}), whereas the lowest yield (2.52 t ha^{-1}) was recorded from T₁. The superior performance of T₄ may be attributed to its balanced plant density (31 m^{-2}) and effective weed suppression through the integrated use of herbicide and manual weeding (Hossain *et al.*, 2024; Abbas *et al.*, 2018). Mandal & Mukherjee (2018) and Jena *et al.* (2017) also demonstrated that Pendimethalin combined with cultural weed control effectively reduces early weed competition and enhances fibre yield in jute. The observed yield increase aligns with findings by Hossain *et al.* (2023), who emphasized that optimum sowing density coupled with efficient weed control extends the critical weed-free period, thereby increasing biomass accumulation and fibre production. Moreover, Swanton *et al.* (2015) highlighted that maintaining jute fields weed-free during the first 40 days after sowing significantly boosts yield, validating the results obtained in this study.

3.4 Stick Yield

Stick yield (SY) followed a trend similar to fibre yield, with the highest value (6.64 t ha^{-1}) recorded in T₄, followed by T₆ (6.34 t ha^{-1}) and T₅ (6.25 t ha^{-1}). The lowest stick yield (4.86 t ha^{-1}) was recorded in T₁. The increase in stick yield under moderate density conditions is mainly due to improved stem elongation and biomass partitioning efficiency (Mukul *et al.*, 2021; Mahbub &

Bhuiyan, 2021). These findings are consistent with the results of Chakraborty *et al.* (2020), who reported that the integration of mechanical and herbicidal weed control enhances stem growth and fibre-stick ratios in *C. olitorius*. The strong correlation between fibre and stick yield also suggests that treatments enhancing vegetative growth can simultaneously improve total biomass productivity (Islam *et al.*, 2017; Zimdahl & Basinger, 2024).

3.5 Effect of Integrated Weed Management

The overall findings confirm that integrated weed management combining Pendimethalin 33% EC with hand weeding was superior to single control measures. This integrated approach ensured early weed suppression, minimized manual labour demand, and improved fibre quality. Such synergy between cultural and chemical control methods has been well-documented in earlier studies by Ghorai (2015), Singh *et al.* (2015), and Mahajan & Chauhan (2013). According to Bhuiyan *et al.* (2018), pre-emergence herbicides like Pendimethalin and Pretilachlor selectively control annual weeds without adversely affecting crop growth, provided they are applied at appropriate doses and timings. The integration of herbicidal and manual weeding approaches represents a sustainable agronomic strategy for improving resource-use efficiency, especially under the labour constraints and rising production costs prevailing in Bangladesh (Akter *et al.*, 2020; Anonymous, 2022). Moreover, Abbas *et al.* (2018) and Hossain *et al.* (2024) emphasized that combining chemical and cultural methods reduces the risk of herbicide resistance while maintaining environmental safety, aligning with modern principles of sustainable jute production.

3.6 Overall Performance

The results clearly demonstrate that the intermediate seed rate of 4.5 kg ha⁻¹ live seed with integrated Pendimethalin 33% EC + one hand weeding (T₄) achieved the most favourable combination of plant density, morphology, and fibre yield. Treatments with very high or very low seed rates were suboptimal due to either excessive plant competition or inadequate plant stand establishment. Similar patterns have been documented in other fibre and field crops, where intermediate densities maximize yield by balancing intra-specific competition and canopy utilization (Susha *et al.*, 2018; Charles *et al.*, 2019). Thus, moderate seed density with integrated weed control proved most effective for optimizing jute productivity under the agro-climatic conditions of Kishoreganj. These results align with previous findings by Hossain *et al.* (2023) and Kumar *et al.* (2015), confirming that the adoption of balanced sowing density and integrated weed management is a key strategy for sustainable yield enhancement in *Corchorus olitorius* L.

Table 1. Yield and yield contributing characteristics of BJRI Tossa Pat 8 in Kishoreganj

Treatments	PP (m ²)	PH (m)	BD (mm)	FY (tha ⁻¹)	SY (tha ⁻¹)
T ₁	19.00f	3.51a	20.30a	2.52e	4.86c
T ₂	23.33e	3.40b	18.13b	2.80d	5.27c
T ₃	27.33d	3.31c	16.13c	3.09c	5.98b
T ₄	31.00c	3.42b	16.20c	3.50a	6.64a
T ₅	36.00b	3.20d	15.10d	3.31b	6.25ab
T ₆	42.00a	3.10e	14.75d	3.37b	6.34ab
LSD (0.05%)	2.43	0.07	0.85	0.11	0.52
% CV	4.50	1.23	2.81	2.07	2.22

Values with different letters are significantly different at $P < 0.05$

Legends: T₁ = 3.0 kg ha⁻¹ live seed + 3.00 kg ha⁻¹ filling materials + Hand Weeding at 25 DAS, T₂ = 3.5 kg ha⁻¹ live seed + 2.5 kg ha⁻¹ filling materials + Pretilachlor 50 EC and One Hand Weeding at 25 DAS, T₃ = 4.0 kg ha⁻¹ live seed + 2.00 kg ha⁻¹ filling materials + One Hand Weeding at 25 DAS, T₄ = 4.5 kg ha⁻¹ live seed + 1.5 kg ha⁻¹ filling materials + Pendimethilin 33% EC + One Hand Weeding at 25 DAS, T₅ = 5.0 kg ha⁻¹ live seed + 1.00 kg ha⁻¹ filling materials + One Hand Weeding at 25 DAS and T₆ = 5.5 kg ha⁻¹ live seed + One Hand Weeding at 25 DAS BJRI tossa pat-8 will be used as variety

b) For Jute Research substation Station, Jashore

3.7 Plant Population

Plant population per square meter (PP) was significantly affected ($P < 0.05$) by the seed rate and weed management treatments (Table 2). The maximum plant population (43.00 m⁻²) was observed in T₆ (5.5 kg ha⁻¹ live seed + one hand weeding), while the lowest (19.50 m⁻²) occurred in T₁ (3.0 kg ha⁻¹ live seed + 3.0 kg ha⁻¹ filler + hand weeding). The progressive increase in plant density with higher seed rates agrees with the expected trend of enhanced stand establishment under greater seed input (Karimi *et al.*, 2021; Kumar *et al.*, 2015). However, excessively dense stands often lead to competition among plants for light, moisture, and nutrients, resulting in thinner stems and reduced individual plant performance (Morsy & Tantawy, 2018; Ghorai, 2015). Similar results were reported by Islam & Ali (2017) and Ngomuo *et al.* (2017), who emphasized that a balanced seeding rate promotes uniform stand establishment, contributing to optimum plant density and overall productivity in jute.

3.8 Plant Height and Base Diameter

Significant differences in plant height (PH) and base diameter (BD) were recorded among the treatments. The tallest plants (3.56 m) and the largest stem diameter (20.50 mm) were found in T₁, while the shortest plants (3.10 m) and the smallest stem diameter (14.90 mm) were recorded from T₆. These findings indicate that lower planting density allows better access to growth resources and light, enabling greater stem elongation and radial growth (Charles *et al.*, 2019; Susha *et al.*, 2018). Similar results were reported by Singh *et al.* (2015) and Mandal & Mukherjee (2018), who observed that lower seeding rates produced taller and thicker jute plants due to reduced intra-plant competition. On the other hand, denser stands, while ensuring higher total plant populations, tended to reduce individual growth parameters, consistent with the observations of Korres & Norsworthy (2015) and Hossain *et al.* (2023). This trade-off between plant density and individual

growth emphasizes the need for optimizing seed rates for maximizing both fibre quantity and quality.

3.9 Fibre Yield

The fibre yield (FY) of *C. olitorius* was significantly influenced by seed rate and weed management combinations. The highest fibre yield (3.60 t ha^{-1}) was recorded in T₄ (4.5 kg ha^{-1} live seed + 1.5 kg ha^{-1} filler + Pendimethalin 33% EC + one hand weeding), followed by T₆ (3.45 t ha^{-1}) and T₅ (3.38 t ha^{-1}), while the lowest yield (2.60 t ha^{-1}) was obtained from T₁. The superior performance of T₄ may be attributed to its moderate plant density (32.10 m^{-2}), which provided a balanced canopy structure, efficient utilization of available resources, and effective weed suppression through the combined application of herbicide and manual weeding. These findings are consistent with the reports of Mandal & Mukherjee (2018) and Jena *et al.* (2017), who noted that integrated weed management practices combining Pendimethalin with manual weeding significantly improved fibre yield in jute. Hossain *et al.* (2024) also demonstrated that judicious herbicide use reduces early weed competition, thereby extending the critical weed-free period and enhancing fibre yield. The results further corroborate the findings of Abbas *et al.* (2018) and Bhuiyan *et al.* (2018), who observed that combining herbicides with cultural practices can increase productivity by reducing crop–weed competition during early growth stages. The relatively higher yield at Jashore compared to Kishoreganj may be due to more favourable climatic conditions and soil fertility, promoting enhanced fibre accumulation under the same management regimes.

3.10 Stick Yield

Stick yield (SY) exhibited a similar trend to fibre yield. The highest stick yield (6.72 t ha^{-1}) was recorded in T₄, followed by T₆ (6.40 t ha^{-1}) and T₅ (6.30 t ha^{-1}), while the lowest (4.95 t ha^{-1}) was obtained from T₁. The increase in stick yield under moderate density conditions was likely due to improved stem elongation and biomass accumulation resulting from optimal spacing and reduced competition (Mukul *et al.*, 2021; Mahbub & Bhuiyan, 2021). The results align with Chakraborty *et al.* (2020), who reported that integrated mechanical and chemical weed management enhanced total dry matter production and fibre-stick yield ratios in tossa jute. Furthermore, Hossain *et al.* (2023) indicated that maintaining weed-free conditions during early crop growth significantly increased total biomass yield, similar to the results observed in this study.

3.11 Integrated Weed Management and Agronomic Efficiency

The treatments combining herbicide application with manual weeding (T₂ and T₄) performed consistently better than single control methods, underscoring the benefits of integrated weed management (IWM). The application of Pendimethalin 33% EC effectively controlled annual weeds, while supplementary hand weeding ensured the removal of late-emerging species, enhancing overall crop performance (Hossain *et al.*, 2024; Mahajan & Chauhan, 2013). Similar synergistic effects were reported by Ghorai (2015) and Singh *et al.* (2015), who found that integrating chemical and manual control methods improved jute yield and reduced weed biomass by over 60%. The superior results obtained under IWM align with Abbas *et al.* (2018), who emphasized the sustainability of integrated approaches to prevent herbicide resistance and reduce environmental impacts. Additionally, Swanton *et al.* (2015) stressed that maintaining crops weed-free during their critical growth stages is vital for maximizing yield potential, supporting the outcomes of this experiment. Hence, the integration of Pendimethalin with limited manual

weeding appears to be the most effective and labour-efficient strategy for achieving high yields in jute under Jashore conditions.

3.12 Overall Performance

Overall, the moderate seed rate of 4.5 kg ha⁻¹ live seed + 1.5 kg ha⁻¹ filler combined with Pendimethalin 33% EC and one hand weeding (T₄) consistently produced the highest fibre and stick yields at Jashore. Treatments with higher or lower seeding rates were less efficient due to either excessive plant competition or inadequate stand establishment. These findings are consistent with previous reports by Kumar *et al.* (2015) and Hossain *et al.* (2023), who concluded that intermediate seeding densities and integrated weed control enhance both the physiological and economic efficiency of jute cultivation. The results also confirm that Jashore's agro-ecological conditions favour higher biomass accumulation compared to Kishoreganj, as reflected in slightly increased yield levels under similar management. This may be attributed to better soil aeration, higher temperature, and more favourable light interception, all of which promote fibre deposition (Islam & Ali, 2017; Anonymous, 2022). The findings reaffirm that the adoption of region-specific integrated management practices can significantly contribute to the sustainable intensification of jute production in Bangladesh.

Table 2. Yield and yield contributing characteristics of BJRI Tossa Pat 8 in Jashore

Treatments	PP (m ²)	PH (m)	BD (mm)	FY (tha ⁻¹)	SY (tha ⁻¹)
T ₁	1950f	3.56a	20.50a	2.60e	4.95c
T ₂	24.00e	3.36b	17.80b	2.90d	5.35c
T ₃	28.20d	3.28c	16.40c	3.15c	6.10b
T ₄	32.10c	3.46b	16.50c	3.60a	6.72a
T ₅	37.00b	3.15d	15.20d	3.38b	6.30ab
T ₆	43.00a	3.10e	14.90d	3.45b	6.40ab
LSD (0.05%)	2.50	0.09	0.90	0.13	0.55
% CV	4.60	1.28	2.90	2.15	2.30

Values with different letters are significantly different at P<0.05

Legends: T₁ = 3.0 kg ha⁻¹ live seed + 3.00 kg ha⁻¹ filling materials + Hand Weeding at 25 DAS, T₂ = 3.5 kg ha⁻¹ live seed + 2.5 kg ha⁻¹ filling materials + Pretilachlor 50 EC and One Hand Weeding at 25 DAS, T₃ = 4.0 kg ha⁻¹ live seed + 2.00 kg ha⁻¹ filling materials + One Hand Weeding at 25 DAS, T₄ = 4.5 kg ha⁻¹ live seed + 1.5 kg ha⁻¹ filling materials + Pendimethalin 33% EC + One Hand Weeding at 25 DAS, T₅ = 5.0 kg ha⁻¹ live seed + 1.00 kg ha⁻¹ filling materials + One Hand Weeding at 25 DAS and T₆ = 5.5 kg ha⁻¹ live seed + One Hand Weeding at 25 DAS BJRI tossa pat-8 will be used as variety

4. Conclusion

The findings of this study demonstrate that optimizing seed rate and integrating herbicidal weed management can significantly improve jute yield and quality. Among the six treatment combinations, the moderate seeding rate of 4.5 kg ha⁻¹ live seed with 1.5 kg ha⁻¹ filler material, supplemented with Pendimethalin 33% EC and one hand weeding at 25 DAS, consistently produced the highest fibre and stick yields across both Kishoreganj and Jashore regions. This combination provided balanced plant density, efficient weed suppression, and improved resource

utilization. Hence, this integrated approach offers a practical and sustainable strategy for enhancing fibre productivity and reducing labour dependency in Tossa jute cultivation across diverse agro-climatic zones of Bangladesh.

5. Declarations

Data availability statement

The data supporting this study will be made available upon reasonable request.

Declaration of Interest statement

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Additional information

No additional information is available for this paper.

Disclaimer (Artificial intelligence)

The author (s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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