Iraqi Journal of Desert Studies 2026, 16 (1): 43-50 **Original Article**

Optimizing Millet Yield Using Planting Dates and Harvest Frequency with Genotypic Variation for Sustainable Production and Land Degradation Mitigation

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Abstract

A field experiment was conducted during the 2023-2024 growing season at Al-Raed Research Station in Iraq to evaluate the effect of planting dates and harvest frequency on forage and grain yields of millet varieties. The experiment was designed as a randomized complete block design (RCBD) with nested subplots and three replicates. The treatments included three planting dates (March 15, March 30, and April 15), three harvest frequencies (no harvest, one harvest, and two harvests), and three varieties (ICM 177004, Ashana, and Wad Al-Bashir). The results showed that planting on March 30 significantly increased the number of branches, spike density, and chlorophyll content, while early planting (March 15) increased plant height and the number of days required for flowering. Harvesting frequency also significantly affected growth, with double harvesting reducing plant height and increasing chlorophyll content. The Wad Al-Bashir genotype showed superior performance compared to the other genotypes for most of the studied traits. The findings indicate that optimizing planting date and mowing frequency plays a crucial role in improving both forage and grain yield of millet. Planting on March 30 combined with appropriate mowing management achieved the best overall performance, while the Wad Al-Bashir genotype demonstrated superior adaptability under the studied conditions. These results highlight the importance of integrated agronomic practices to maximize millet productivity.

Keywords: millet crop, sowing date, mowing, genotype performance, forage yield.

تحسين إنتاج الدخن باستخدام مواعيد الزراعة والحش وتراكيب وراثية لتعزيز الإنتاجية واستدامة النظم الزراعية وتقليل ضغط تدهور الأراضي

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المستخلص

اجريت تجربة حقلية خلال الموسم 2023–2024 في الحقول التابعة لمحطة أبحاث الرائد بهدف دراسة تأثر حاصل العلف والبذور لتراكيب وراثية من الدخن بمواعيد الزراعة والحش. تم تنفيذ التجربة في تصميم القطاعات كاملة العشوائية RCBD وبترتيب الالواح المنشقة مرتين. اذ تضمنت الالواح الرئيسية مواعيد الزراعة (15–3 و30–3 و15–4) في حين الالواح الثانوية تضمنت معاملات الحش (بدون حش وحش مرة واحدة وحش مرتين) اما الألواح تحت الثانوية احتوت التراكيب الوراثية هي Ashana و ICM177004 و Wad albasher. أظهرت النتائج أن الزراعة في 30 مارس زادت بشكل ملحوظ من عدد الفروع وكثافة السنابل ومحتوى الكلوروفيل، بينما أدت الزراعة المبكرة (15 مارس) إلى زيادة طول النبات وعدد الأيام اللازمة للإزهار. كما أثر تواتر الحصاد بشكل ملحوظ على النمو، حيث أدى الحصاد المزدوج إلى تقليل طول النبات وزيادة محتوى الكلوروفيل. أظهر النمط الوراثي "Wad Albasher" أداءً متفوقًا مقارنةً بالأنماط الوراثية الأخرى في معظم الصفات المدروسة. وتشير النتائج إلى أن تحديد موعد الزراعة الأمثل وتواتر الحصاد يلعب دوراً حاسماً في تحسين كلٍ من محصول العلف والحبوب للدخن. وقد حققت الزراعة في 30 مارس، إلى جانب إدارة الحصاد المناسبة، أفضل أداء إجمالي، بينما أظهر النمط الوراثي "Wad Albasher" قدرةً فائقةً على التكيف مع الظروف المدروسة. وتُبرز هذه النتائج أهمية الممارسات الزراعية المتكاملة لزيادة إنتاجية الدخن إلى أقصى حد.

الكلمات المفتاحية: محصول الدخن، مواعيد الزراعة، تكرار الحش، أداء التراكيب الوراثية، إنتاجية العلف

Introduction

As competition for fresh water intensifies, the utilization of groundwater pumping in irrigated agriculture is Genetic materials is one of the maximum vital pillars on which the rural region's fulfillment is based totally; that is carried out thru genetic improvement processes that suit the wishes or desires of plant breeders. The distinction in genotype overall performance below the same environmental conditions is one of the maximum crucial necessities of diverse breeding applications. This allows the production of hybrids or synthetic genotypes that boom production (Abed and Al-Essawi, 2024). Maurya et al. (2016) stated that genotypes had a giant effect, with genotype V3 yielding the highest average plant height of 162.06 cm. The results of Bramhaiah *et al*. (2018) indicated huge differences among genotypes in plant top and tiller number. Ebonka *et al*. (2019) located

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incredible variant among pearl millet genotypes, with the Gero bedeggi genotype yielding the best averages for the studied developments: plant height, number of tillers, flag leaf area, and variety of days from planting to 50% flowering. These will increase were attributed to genetic variations that have an effect on plant hormone activity.

Planting date is a basic thing that influences plant boom and productiveness. The preference of appropriate planting dates affects the duration of development and, therefore, the physiological and morphological developments of plant life. For example, early planting can provide higher get right of entry to environmental assets, consisting of sunlight and water, at the same time as late planting can reduce publicity to high temperatures. In addition, planting dates have an effect on flowering and fruiting time, which without delay affect seed yield and forage accumulation (Al-Essawi and Abed, 2020 and Abdulhamed *et al*.,2024).

Cutting frequency is a pivotal issue for twin-cause crops like millet. Improper or excessive cutting can lessen yield additives and grain manufacturing, normally through reducing leaf vicinity and inflicting premature stem senescence in the course of reproductive tiers (Waheddullah, 2018). To make sure most suitable regrowth and sustained productiveness after reducing, coordinated management of sowing time and cutting schedules is essential. Hussein *et al*. (2021) stated that reducing frequency extensively affected panicle density in step with rectangular meter: the no-cut remedy produced the highest common (473.35 panicles m^{-2}), at the same time as the single- and double-cut remedies yielded notably lower averages (468.85 and 389.26 panicles m^{-2}, respectively). This decline changed into attributed to inadequate restoration time for tillers to increase panicles and depletion of the plant's carbohydrate reserves. Salama (2019) further cited that early cutting of barley at 45 and 55 days after sowing (DAS) improved maximum measured trends compared to

later slicing at 65 DAS, highlighting the importance of timing in put up-slicing recovery and yield formation.

This study aimed to evaluate the effects of sowing dates, cutting management, and genetic variation on forage and grain yield of millet, in order to identify the most efficient agronomic practices and genotypes for improving productivity under arid and semi-arid conditions, thereby supporting the sustainability of agroecosystems

Materials and Methods

A field test becomes conducted throughout 2023 - 2024 seasons at the fields of the Ministry of Water Resources (Al-Raed Research Station), Baghdad, Iraq. The purpose changed into to examine the outcomes of planting date and reducing frequency on forage and seed yields of newly delivered millet genotypes in Iraq. The experiment became implemented the usage of a Randomized Complete Block Design (RCBD) arranged in a break up break up Plot design. The main plots included 3 sowing dates (March 15^{th} and 30^{th}, and April 15^{th}), particular as D1, D2, and D3, respectively. The subplots covered reducing frequencies (no cutting, one cut, and two cuts), coded as M1, M2, and M3, respectively. The sub-subplots consisted of the genotypes ICM77004, Ashara, and Wadultr, coded as V1, V2, and V3, respectively.

The soil becomes plowed two times perpendicularly the use of a moldboard plow followed by harrowing and right leveling. The test was divided into plots measuring 9 m^2 (3×3m). Potassium fertilizer turned into carried out at a rate of 40 kg ha^{-1} within the form of P_2O_5 for the duration of land guidance (Singh *et al*., 2017). Nitrogen fertilizer became implemented at a charge of 60 kg ha^{-1} as urea, cut up into 3 doses: the primary at 25 days after emergence, and the ultimate after every slicing (Shekara *et al*., 2019). Stem borer control changed into achieved 30 days after sowing using cypermethrin insecticide (Attri *et al*., 2024).

Traits studied

1. Plant height (cm): It was measured from the soil floor to the panicle node for 10 flora in line with experimental unit.
2. Days to 100% flowering: Number of days from sowing to finish flowering.
3. Number of tillers (tiller $plant^{-1}$).
4. Number of tillers (tillers m^{-2}): It was determined via counting tillers within a 1 m^2 location from each experimental unit.
5. Panicle density (panicles m^{-2}): Similarly, panicles had been counted within a 1 m^2 area per plot to assess reproductive capability.

Statistical analysis

Data analysis becomes carried out using GenStat software. Means have been as compared using the Least Significant Difference (LSD) test at a zero.05% importance level.

Results and Discussion

Plant height (cm)

The consequences of table1 discovered a considerable impact of sowing date on plant peak. The maximum Planting date, D1 (March 15st), yielded the very best average plant peak of one hundred 35.04 cm. Date D3 (April 15 th) recorded the lowest average of 116.33 cm. This upward push in plant height with early sowing may be associated with advanced vegetative boom, because the crop may take advantage of favorable temperature conditions. This locating aligns with the results of Moreno et al. (2014), who concluded that the correct planting date provides the crop with a better opportunity to benefit from appropriate temperatures.

The effects of Table 1 showed the cutting frequency impacts the plant's peak. The no-reducing M1 flora owns the most important height 129.81 cm, at the same time as the double cut M3 flowers had been the shortest (120). It is regular with Al-Taei (2016), who stated that repeated cuttings intrude with apical dominance and shift plant growth power away from elongation and toward the later branching device and tillering, thereby decreasing normal plant height.

Genotypes demonstrated significant differences in plant height. Genotype V3 recorded the highest average of 140.52 cm, while genotype V1 gave the lowest average of 113.15 cm. This variation can be attributed to the genotypes ' genetic makeup.

The results in table2,3, and4 the tow-factor interactions of sowing dates x cutting , sowing dates x genotypes, and cutting x genotypes resulted in relative response ranges of 25.6%,39.87%, and 32.43% respectively.

The results in Table 5 also confirmed that the three-way interaction between planting dates, harvest dates, and genotypes had a significant effect on the same trait, as the combination D1 x M1 x V3 gave the highest mean score of 170 cm compared to the other combinations, with combination D3 x M3 x V1 giving the lowest mean score 90.67 cm.

Days from sowing to 100% flowering (days)

The results of Table 1 Planting date significantly influenced the number of days required to reach 100% flowering. The earliest planting (D3-April 15 th5t) resulted in the longest duration 114.52 days, while the latest planting (D2–March 30th) triggered the earliest flowering and recorded the shortest duration95.81 days. This is likely due to photoperiodic and thermal responses, which delay sowing and expose plants to shorter day lengths and warmer temperatures, which accelerate floral initiation.

The results of Table 1 Cutting frequency significantly affected flowering time. Plants subjected to two cuts M3 took the longest to flower 115.52 days, whereas those cut once M1 flowered earliest 94.96 days. This delay under repeated cutting can be attributed to the plant’s compensatory response: cutting stimulates branching and prolongs vegetative growth as the plant reallocates resources to regenerate biomass before transitioning to reproduction.

Significant differences were observed among genotypes. Genotype V3 exhibited the highest mean of 112.89 days, whereas genotype V2 gave the lowest mean of 94.19 days. These variations may be related to genetic differences among genotypes and their varying sensitivity to photoperiod.

The results in Table2, 3, and 4 The interaction between sowing and harvesting dates was not statistically significant; however, the interaction between sowing and varieties, and harvesting and varieties, showed a measurable relative response 42.48% and 38.46% respectively.

The results in Table 5 were not statistically significant.

Number of Tillers (tiller plant^{-1})

The results of Table 1 revealed that planting dates significantly affected total tillers plany^{-1}. Sowing date D2 (March 30th) yielded the highest average of 8.919 tillers plant^{-1}, whereas the D1 (March 15th) resulted in a lower average of 6.589 tillers plany^{-1}, and this agreed with the results of Al-Rifai and Abdul Wahid (2019), and the reason for this was attributed to the effect of suitable temperatures that promote tiller formation and increasing nutrient uptake.

Cutting frequency significantly influenced the number of tillers. treatment M2 recorded the highest mean of 8.374 tiller plant^{-1}, while M3 resulted in the lowest average of 6.744 tiller plant^{1}, and this agrees with El Mouttaqi et al. (2023), who attributed the reason to the role of the genotypes ' inherent genetic characteristics.

Table results 1 Significant difference was observed among genotypes with respect to tiller number, with genotype V3 achieving the highest mean 7.74 tiller plant^{-1}, while genotype V1 showed the lowest mean (6.90 tiller plant^{-1}.

The results in table2,3, and4 the tow-factor interactions of sowing dates x cutting, sowing dates x genotypes, and cutting x genotypes resulted in relative response ranges of 60.54%,45.45%, and 47.55% respectively.

The results in Table 5 also confirmed that the three-way interaction between planting dates, harvest dates, and genotypes had a significant effect on the same trait, as the combination D2 x M2 x V3 gave the highest mean score of 12.33 tiller m^{-2} compared to the other combinations, with combination D3 x M3 x V1 giving the lowest mean score 5.2 tiller m^{-2}.

Number of panicles (panicle m^{-2})

According to the data in Table 1, considerable differences had been determined among sowing dates within the range of panicles. Sowing date D2 produced the very best suggest cost 85.85 panicle m^{-2}, while the lowest mean 49.41 panicle m^{-2} turned into recorded for sowing date D3.

cutting treatments differed significantly in this trait, with M2 giving the highest mean 72.11 panicle m^{-2} and M3 the lowest (60.78 panicle m^{-2}) , and this finding aligns with the results of Nand *et al*. (2019), who indicated that cutting barley crop led to higher number of spikes per unit area. The reason returns to breaking apical dominance and allowing tillers to grow better.

Significant differences were observed among genotypes for this trait (Table 1), with genotype V1 achieving the highest mean (77), while genotype V2 recorded the lowest mean 60.

The results in Table 2, 3, and 4 the two-factor interactions of sowing dates x cutting, sowing dates x genotypes, and cutting x genotypes resulted in relative response ranges of 79.87%,86.71%, and 40% respectively.

The results in Table 5 also confirmed that the three-way interaction between planting dates, harvest dates, and genotypes had a significant effect on the same trait, as the combination D2 x M2 x V2 gave the highest mean score of 11.07 panicles m^{-2} compared to the other combinations, with combination D1 x M2 x V1 giving the lowest mean score 4.13 panicles m^{-2}.

Table 1. Effect of mowing, planting date, and varieties on traits pH, Flowering, Tillers, Panicles, green fodder , and dry fodder

	Plant height (cm)	Days from sowing to 100% flowering (days)	Number of tillers (tillers m^{-2})	Number of panicles (panicles m^{-2})	green fodder yield(t h^{-1})	Dry fodder (t h^{-1})
D1	51.393	59.26	7.141	59.93	4.333	0.569
D2	53.493	55.44	7.496	77.15	5.808	0.795
D3	55.363	61.78	8.244	62.85	5.607	0.683
LSD 5%	1.81	0.57	0.056	3.42	1.6	0.05
M1	52.219	61.3	7.363	64.59	0	0
M2	53.459	60.44	8.926	85.74	5.092	0.665
M3	54.57	54.74	6.593	49.59	10.657	1.383
LSD 5%	0.87	0.76	0.126	3.53	0.63	0.02
V1	52.222	70.11	8.133	72.07	5.977	0.79
V2	53.415	55.52	7.659	66.93	5.357	0.673
V3	54.611	50.85	7.089	60.93	4.415	0.585
LSD 5%	1.67	0.57	0.079	2.72	0.25	0.01

Table 2. Effect of interaction D x M on Plant height (cm), Days from sowing to 100% flowering (days), Number of tillers (tillers m^{-2}), Number of panicles (panicles m^{-2}), Green fodder (t h-1) and dry fodder (t h-1)

		Plant height (cm)	Days from sowing to 100% flowering (days)	Number of tillers (tillers m^{-2})	Number of panicles (panicles m^{-2})	green fodder ($t\,h^{-1}$)	dry fodder ($t\,h^{-1}$)
D1	M1	141.89	87.33	6.322	82.11	0	0
	M2	125.67	84.78	8.6	49.22	4.317	0.572
	M3	121.89	112.78	6.611	69.67	8.683	0.677
D2	M1	135.56	89	7.122	55	0	0
	M2	126.22	92.44	10.822	97.22	5.527	0.747
	M3	117.33	107.67	7.178	64.11	11.898	1.136
D3	M1	127.67	113.22	6.322	78.22	0	0
	M2	122.56	110.22	7.333	44	5.433	1.374
	M3	109.78	123.11	6.578	60.11	11.389	1.638
LSD 5%		5.211	NS	0.3225	5.628	1.09	0.03

Table3. Effect of interaction D V on Plant height (cm), Days from sowing to 100% flowering (days), Number of tillers (tillers m^{-2}), Number of panicles (panicles m^{-2}), green fodder (t h-1), and dry fodder (t h-1)

	Plant height (cm)			Days from sowing to 100% flowering (days)		
DV	123.22	129.78	152.11	97.78	90.44	101.33
	114.11	122.56	137.78	90.67	93.33	103.44
	102.11	115.22	131.67	110.89	98.78	133.89
LSD 5%	5.138			8.236		
	Number of tillers (tillers m^{-2})			Number of panicles (panicles m^{-2})		
DV	6.222	6.956	6.589	66.56	62.56	64.78
	8.089	9.067	9.6	100.89	75.89	80.78
	6.4	6.933	7.033	63.56	41.56	43.11
LSD 5%	0.4007			5.872		
	green fodder (t h-1)			dry fodder (t h-1)		
DV	3.775	4.294	4.933	0.494	0.572	0.641
	4.661	5.954	6.809	0.661	0.799	0.925
	4.811	5.822	6.189	0.599	0.648	0.803
LSD 5%	0.44			0.02		

Table 4. Effect of interaction M V on Plant height (cm), Days from sowing to 100% flowering (days), Number of tillers (tillers m^{-2}), Number of panicles (panicles m^{-2}), Green fodder ($t\,h^{-1}$), and dry fodder ($t\,h^{-1}$)

	Plant height (cm)			Days from sowing to 100% flowering (days)		
M V	117.22	125.11	147.11	90.67	91.78	102.44
	115.78	124.44	138.89	92.22	88.33	108.56
	106.44	118	135.56	116.44	102.44	127.67
LSD 5%	3.827			6.246		
	Number of tillers (tillers m^{-2})			Number of panicles (panicles m^{-2})		
M V	5.333	6.933	7.967	79.44	58.78	62.78
	8.556	7.7	8.867	78.22	68.44	69.67
	6.822	8.322	6.389	73.43	52.78	56.22
LSD 5%	0.39			3.85		
	green fodder (t h-1)			dry fodder (t h-1)		
M V	0	0	0	0	0	0
	5.992	5.118	4.167	0.551	0.674	0.769
	11.939	10.953	9.078	1.202	1.345	1.6
LSD 5%	0.44			0.02		

Green fodder yield (t h^{-1})

The results revealed a full-size effect of sowing date on green fodder yield. The sowing date D2 produced the very best mean cost of 5.808 t h^{-1}, at the same time as D1 gave the bottom mean of 4.333 t h^{-1}.

Cutting frequency considerably affected green fodder yield. The remedy M3 produced the best imply of 10.657 t h^{-1}, while the only-reduce treatment M2 produced the bottom mean of 5.092 t h^{-1}

The genotypes differed drastically in their chlorophyll content material. Genotype V1 exhibited the highest mean of 5.977 t h^{-1}, at the same time as genotype V3 gave the lowest imply of 5.357 t h^{-1}. This variant is probably due to the genetic characteristics of the genotypes and their potential to make use of to be had soil vitamins, which, in flip, have an impact on chlorophyll synthesis.

The results in table2,3, and4 the tow-thing interactions of sowing dates x cutting, sowing dates x genotypes, and reducing x genotypes resulted in relative reaction ranges of eleven.103.26 %, 65.28%, and 105.96% respectively. The results in Table 5 also confirmed that the three-way interaction between planting dates, harvest dates, and genotypes had a significant effect on the same trait, as the combination D2 x M2 x V3 gave the highest mean score of 1.633 t h^{-1} compared to the other combinations, with combination D1 x M2 x V1 giving the lowest mean score 3.417 t h^{-1}.

Dry fodder (t h^{-1})

The results revealed a full-size effect of sowing date on Dry fodder yield . The sowing date D2 produced the very best mean cost of 0.795 t h^{-1}, at the same time as D1 gave the bottom mean of 0.569 t h^{-1}.

Cutting frequency considerably affected green fodder yield. The remedy M3 produced the best imply of 1.383 t h-1, while the only-reduce treatment M2 produced the bottom mean of 0.665 t h^{-1}.

The genotypes differed drastically in their chlorophyll content material. Genotype V1 exhibited the highest mean of 1.383 t h^{-1}, at the same time as genotype V3 gave the lowest imply of 0.673 t h^{-1}. This variant is probably due to the genetic characteristics of the genotypes and their potential to make use of to be had soil vitamins, which, in flip, have an impact on chlorophyll synthesis.

Table 5. Effect of interaction D M V on Plant height (cm), Days from sowing to 100% flowering (days), Number of tillers (tillers m^{-2}), Number of panicles (panicles m^{-2}), Green fodder (t h-1), and dry fodder (t h-1)

		Plant height (cm)			Days from sowing to 100% flowering (days)		
D1	M1	124.33	131.33	170	87.67	87	87.33
	M2	114.67	125	137.33	77.67	86.67	90
	M3	112.67	119	134	106.67	101.67	130
D2	M1	127.67	134	145	87.33	86.33	93.67
	M2	116.67	124.33	137.67	84.33	88.67	104.33
	M3	103	115	134	105	90.33	127.67
D3	M1	117.67	124	141.33	118.33	98.33	123
	M2	111	118.33	138.33	110	104.67	116
	M3	90.67	111.67	127	121	104.33	144
LSD 5%		9.55			NS		
		Number of tillers (tillers m^{-2})			Number of panicles (panicles m^{-2})		
D1	M1	6.6	6.07	6.3	4.73	5.43	6.77
	M2	5.6	10.2	6.27	4.13	8.8	4.7
	M3	6.67	6.77	6.4	5.53	5.77	4.8
D2	M1	6.87	7.2	7.3	6.23	6.4	6.5
	M2	11.47	12.33	8.67	9.4	11.07	7.5
	M3	7.33	7.07	7.13	6.53	6.43	6
D3	M1	5.23	6.5	7.27	5.47	5.93	5.67
	M2	7.2	6.33	12.27	6.73	5.5	10.6
	M3	5.2	7.27	7.27	4.27	6.27	5.7
LSD 5%		0.65			1.09		
		green fodder (t h^{-1})			dry fodder (t h^{-1})		
D1	M1	0	0	0	0	0	0
	M2	3.417	4.25	5.283	0.46	0.581	0.675
	M3	7.9	8.633	9.517	0.574	0.678	0.778
D2	M1	0	0	0	0	0	0
	M2	4.517	5.603	6.46	0.62	0.764	0.856
	M3	9.467	12.26	13.967	1.022	1.136	1.249
D3	M1	0	0	0	0	0	0
	M2	4.567	5.5	6.233	1.223	1.266	1.633
	M3	9.867	11.967	12.333	1.362	1.63	1.92
LSD 5%		0.76			0.04		

The results in table 2,3, and 4 the tow-thing interactions of sowing dates x cutting, sowing dates x genotypes, and reducing × genotypes resulted in relative reaction ranges of eleven.102.96 % , 48.39% , and 107.08% respectively.

The results in Table 5 also confirmed that the three-way interaction between planting dates, harvest dates, and genotypes had a significant effect on the same trait, as the combination D3 x M2 x V3 gave the highest mean score of 1.633 t h^{-1} compared to the other combinations, with combination D1 x M2 x V1 giving the lowest mean score 0.46 t h^{-1}.

Conclusions

From the above, we conclude that the planting date of 30^{th} March thirtieth drastically contributed to improving tendencies that play a role in growing grain yield, including the wide variety of tillers, the quantity of runners, and chlorophyll content material. The planting date of March 15^{th} improved the plant height trait. Optimal harvesting control progressed tendencies answerable for forage and seed yield. The Wad Walter variety outperformed in maximum of the studied developments. Binary and triple combinations additionally showed huge differences within the studied developments.

Sustainability Statement

This study contributes to sustainable forage production by optimizing planting dates and harvest frequency while evaluating the performance of different millet genotypes under arid and semi-arid conditions. The findings provide practical strategies for increasing forage yield, improving land-use efficiency, conserving natural resources, and mitigating land degradation through sustainable crop management practices adapted to fragile ecosystems.

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Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request. All data generated or analyzed during this study are included in the published article and its supplementary materials, where applicable.

Author Contributions (CRediT)

First author (Postgraduate student): Conceptualization, Methodology, Investigation, Formal analysis, Data curation, Visualization, Writing – original draft. Second author: Supervision, Methodology, Validation, Resources, Writing – review & editing. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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