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Sowing Date and Agronomic Performance of *Panicum maximum* cv. C1 under a Transitional Climate: Forage Biomass, Carrying Capacity and Seed Yield in Bouaké (Côte d'Ivoire)

Kouadja Gouagoua Séverin [a], Koffi Christophe Kobenan [b*], Kouadio Kouakou Eugène [a], Soro Yaraba Raphaël [c], Traore Bèh [c] and Adama Bakayoko [d]

[a] Livestock Production Research Station (SRPEL), National Agricultural Research Centre (CNRA), 10 BP 633 Bouaké 01, Côte d'Ivoire.
[b] Cotton Research Station (SRCOT), National Agricultural Research Centre (CNRA), 10 BP 633 Bouaké 01, Côte d'Ivoire.
[c] Nangui Abrogoua University, UFR of Natural Sciences, Laboratory of Animal Biology and Cytology, 02 BP 801 Abidjan 02, Côte d'Ivoire.
[d] Nangui Abrogoua University, UFR of Natural Sciences, Laboratory of Biodiversity and Sustainable Ecosystem Management, 02 BP 801 Abidjan 02, Côte d'Ivoire.

Authors' contributions

This work was carried out in collaboration among all authors. Author KGS designed the study, conducted the field experiment and wrote the first draft of the manuscript. Author KCK performed the statistical analysis and revised the manuscript. Authors KKE, SYR, TB and AB managed the analyses and the literature searches. All authors read and approved the final manuscript.

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**Corresponding author: E-mail: kobenankoffichristophe@yahoo.fr;*

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Abstract

Aims: To identify the sowing window that jointly optimizes forage biomass and seed quality of *Panicum maximum* cv. C1 at Bouaké, Côte d'Ivoire.
Study Design: Randomized complete block design with three replicates.
Place and Duration of Study: Livestock Production Research Station (SRPEL), National Agricultural Research Centre (CNRA), Gbêkê region, Bouaké, Côte d'Ivoire, from April 2025 to January 2026.
Methodology: Ten sowing dates from 15 May to 30 September were compared. Plant height, tillering, fresh and dry biomass, carrying capacity, crude and cleaned seed yields and germination rate were recorded.
Results: Sowing date had a highly significant effect on all traits ($P < .05$). Sowing on 15 September produced the highest dry biomass (8,409.9 kg DM/ha/semester; 78.01% dry matter) and the highest carrying capacity. Late June and mid-July sowings promoted tillering (77.89 to 82.66 tillers). Seed production occurred only for May to July sowings: the best cleaned-seed yields were obtained on 30 May (198.9 kg/ha) and 15 June (151.1 kg/ha), with germination rates reaching 46.3%. August and September sowings produced no usable seed.
Conclusion: Two practical windows emerge: mid-May to mid-June for quality seed production, and mid-September to maximize biomass and animal load. These calendar benchmarks provide a simple lever for forage intensification under a transitional climate.

Keywords: Tillering; germination rate; tropical livestock unit; sown pasture; bimodal rainfall.

1. Introduction

Ruminant livestock remains a pillar of food security in West Africa. In Côte d'Ivoire the sector is still largely extensive: about 95% of the animals' diet still comes from natural rangelands (FAO, 2016; MIPARH, 2003). These rangelands are exposed to overgrazing, degradation and a reduction of available area under the effects of urbanization (Dembélé *et al.*, 2007; Kouakou *et al.*, 2010). Feed is therefore a major limiting factor and can account for nearly half of production costs.

Cultivated forage grasses provide an operational response to this seasonal deficit. Among them, *Panicum maximum* Jacq. (Guinea grass) occupies a central place in tropical systems because of its rapid growth, regrowth capacity and acceptable nutritive value when harvested at an appropriate stage (Cook *et al.*, 2005; Euclides *et al.*, 2014). Recent multi-environment trials confirm that herbage dry-matter yield of Guinea grass commonly ranges from about 9 to 15 t/ha depending on genotype and site (Wekgari & Dereba, 2025). Cultivar C1, widely grown in Côte d'Ivoire, is valued for its vigour, tillering and productivity; seed multiplication has become a key issue for securing access to quality planting material (César *et al.*, 1999).

Successful establishment and seed production of *P. maximum* (syn. *Megathyrsus maximus*) nevertheless depend closely on the water regime and the climatic calendar during emergence, flowering and seed maturation (Cook *et al.*, 2005). Seed yield is also sensitive to the timing of management relative to flowering (Joaquín-Cancino *et al.*, 2020). Central Côte d'Ivoire, and Bouaké in particular, has a transitional subequatorial climate, with a long rainy season, a short dry spell in July–August, a short rainy season in September–October, then a long dry season. Interannual variability in the onset and end of the seasons makes the choice of sowing date decisive (Ouattara *et al.,* 2018).

Although the ecological requirements and forage value of *P. maximum* C1 are documented (Skerman & Riveros, 1990; Cook *et al.*, 2005), local references that quantify, in the same trial, the effect of a gradient of sowing dates on growth, biomass, carrying capacity and seed yield remain scarce. Filling this gap would make it possible to establish a simple cropping calendar that can be transferred to farmers and seed-multiplication stations.

This study therefore aims to determine the planting period that jointly maximizes forage biomass production and seed quality of *P. maximum* cv. C1 in Bouaké. The specific objectives are: (i) to quantify the effect of sowing date (from seed) on plant height and tillering; (ii) to estimate biomass and carrying capacity; (iii) to assess seed yields and germination rate.

2. Materials and Methods

2.1 Site and Period

The trial was conducted from April 2025 to January 2026 at the Livestock Production Research Station (SRPEL) of the National Agricultural Research Centre (CNRA), Gbêkê region, Bouaké, Côte d'Ivoire (07°45'00" N; 005°02'48" W; 348 m a.s.l.). The site belongs to the central climatic transition zone, with marked agro-pastoral activity.

2.2 Plant Material and Fertilisation

The plant material consisted of seeds of *Panicum maximum* cv. C1 harvested from the SRPEL seed field. A basal dressing of NPK 15-15-15 was applied at 370 g per 18.2 m² elementary plot, equivalent to about 200 kg/ha.

2.3 Experimental Design

The design was a randomized complete block with one factor (sowing date) and three replicates. Ten treatments were compared: T1 (15 May), T2 (30 May), T3 (15 June), T4 (30 June), T5 (15 July), T6 (30 July), T7 (15 August), T8 (30 August), T9 (15 September) and T10 (30 September). The total area measured 28 m × 15 m (420 m²). Each of the three blocks contained one elementary plot of

each treatment, giving 30 elementary plots of 5.20 m × 3.50 m (18.2 m²). The elementary plot was the experimental unit. Each plot was subdivided into two sampling subplots for within-plot measurements.

2.4 Crop Management

Sowing was done in pockets, 1–2 cm deep, at ten seeds per pocket. After covering and firming, watering twice a day was applied for seven days. Emergence was observed between 7 and 14 days. Thinning left three plants per pocket. Manual weeding was maintained during the first two weeks, then during the first 45 days, to secure canopy establishment.

2.5 Measured Variables

Plant height (from the collar to the tip of the tallest leaf) and tiller number were recorded weekly for five weeks after the appearance of the first tillers, using a measuring tape and direct counting.

Biomass was assessed at 28-day intervals. In each elementary plot, nine tufts were cut 15 cm above ground inside a 1 m² quadrat. Fresh matter was weighed immediately, then an aliquot of known fresh weight was oven-dried at 65 °C to constant weight to estimate dry-matter content. Plot dry-matter yield was obtained as fresh yield × dry-matter fraction, then scaled from the 1 m² quadrat to kilograms per hectare. Yields are reported as kg FM/ha and kg DM/ha over the measurement semester.

Carrying capacity was calculated following Boudet (1991), assuming that one tropical livestock unit (TLU) consumes 6.25 kg DM/day and may remove only one third of the available phytomass, in order to preserve the sward:

CC (TLU/ha) = (Productivity in kg DM/ha × k) / (6.25 × duration of use), where k is the allowable offtake coefficient.

Seed production was estimated by bagging panicles at flowering to recover seed that would otherwise be shed. Seven days after bagging, panicles were cut and stored for one week to complete maturation. After hand threshing, crude seeds were weighed, winnowed and then cleaned (cleaned seeds). A 1 g sample of cleaned seed was used for counting. Germination rate was determined on four replicates of 50 cleaned seeds per lot, placed on moist filter paper and scored after 14 days.

2.6 Statistical Analysis

Data were entered in Microsoft Excel 2016 and analysed by analysis of variance (ANOVA) in SPSS 20.0 under a randomized complete block model, with sowing date as a fixed effect and block as a random effect. The elementary plot was the experimental unit. When the treatment effect was significant at the 5% level, means were separated by Fisher's LSD test. Results are presented as mean ± standard deviation.

3. Results and Discussion

3.1 Growth: Height and Tillering

ANOVA revealed a highly significant effect of sowing date on mean plant height and tiller number (P = .00; Table 1). Late-June (T4), mid-July (T5) and mid-September (T9) sowings stood out for superior vegetative development. T9 reached the maximum height (64.15 ± 13.68 cm), followed by T5 (54.13 ± 9.75 cm) and T4 (51.96 ± 21.39 cm). Tillering was highest for T5 (82.66 ± 25.87 tillers) and T4 (77.89 ± 49.46), followed by T9 (72.18 ± 18.25). In contrast, sowing on 30 September (T10) produced the lowest values (10.11 ± 7.02 cm; 13.40 ± 11.76 tillers). May and mid-June sowings occupied an intermediate position.

Table 1. Mean plant height and tiller number of *P. maximum* cv. C1 according to sowing date (mean ± standard deviation)

Treatment (date)	Height (cm)	Tiller number
T1	34,48 ± 22,84 a	37,05 ± 24,83 ab
T2	30,21 ± 10,92 a	39,83 ± 26,83 a
T3	30,34 ± 8,03 a	41,96 ± 21,77 a
T4	51,96 ± 21,39 c	77,89 ± 49,46 c
T5	54,13 ± 9,75 c	82,66 ± 25,87 c
T6	24,16 ± 7,98 b	29,06 ± 25,28 b
T7	41,76 ± 17,96 e	19,41 ± 12,94 d
T8	29,32 ± 12,11 ab	34,20 ± 23,25 ab
T9	64,15 ± 13,68 f	72,18 ± 18,25 c
T10	10,11 ± 7,02 d	13,40 ± 11,76 d

Different letters indicate a significant difference (LSD, P < .05). Treatment key: T1 = 15 May; T2 = 30 May; T3 = 15 June; T4 = 30 June; T5 = 15 July; T6 = 30 July; T7 = 15 August; T8 = 30 August; T9 = 15 September; T10 = 30 September

3.2 Biomass and Carrying Capacity

The effect of sowing date on fresh- and dry-matter yields was highly significant (P = .018 for FM; P = .000 for DM; Table 2). Sowing on 15 September (T9) stood out clearly: 10,779.9 ± 3,060.8 kg FM/ha/semester and 8,409.9 ± 3,495.0 kg DM/ha/semester,

with a DM content of 78.01%. Sowings from mid-May to mid-July (T1 to T5) and late September (T10) formed an intermediate group, with DM yields between 1,170 and 2,030 kg/ha/semester. Late-July and August sowings (T6, T7, T8) remained the least productive (639.9 to 900.0 kg DM/ha/semester). The mean dry-matter content of the trial was 39.88%.

Carrying capacity over the semester followed the same gradient. T9 had the highest load; T1 to T5 and T10 occupied an intermediate level; T6, T7 and T8 recorded the lowest values ($P < .05$). This ranking confirms that the sowing calendar directly determines the number of TLU that the sward can support without degradation.

Table 2. Fresh matter (FM) and dry matter (DM) yields according to sowing date (mean ± standard deviation)

Treatment	FM (kg/ha/semester)	DM (kg/ha/semester)	DM content (%)
T1	6 290,1 ± 1 967,3 ab	1 940,1 ± 357,9 b	30,84
T2	3 489,9 ± 3 022,5 ab	1 170,0 ± 1 044,8 b	33,52
T3	5 730,0 ± 720,6 ab	1 860,0 ± 120,0 b	32,46
T4	3 960,0 ± 1 818,2 ab	1 560,0 ± 482,8 b	39,39
T5	6 330,0 ± 1 026,6 ab	2 030,1 ± 306,4 b	32,07
T6	1 670,1 ± 1 832,3 b	840,0 ± 825,4 b	50,29
T7	1 940,1 ± 1 689,7 b	900,0 ± 788,6 b	46,39
T8	2 859,9 ± 4 953,7 b	639,9 ± 1 108,5 b	22,37
T9	10 779,9 ± 3 060,8 a	8 409,9 ± 3 495,0 a	78,01
T10	3 800,1 ± 3 810,0 ab	1 269,9 ± 1 232,0 b	33,42

Different letters indicate a significant difference (LSD, $P < .05$). Treatment key: T1 = 15 May; T2 = 30 May; T3 = 15 June; T4 = 30 June; T5 = 15 July; T6 = 30 July; T7 = 15 August; T8 = 30 August; T9 = 15 September; T10 = 30 September

3.3 Seed Yield and Germination

The treatment effect on crude and cleaned seed yields was highly significant ($P = .004$; Table 3). Only sowings from May to July produced seed. T2 (30 May) and T3 (15 June) performed best, with 358.9 ± 198.3 and 295.5 ± 248.2 kg/ha of crude seed, and 198.9 ± 116.9 and 151.1 ± 123.9 kg/ha of cleaned seed, respectively. T1 (15 May) followed (210.0 and 121.1 kg/ha). Late-June to late-July sowings (T4 to T6) dropped sharply (34.4 to 41.1 kg/ha of cleaned seed). T7 to T10 produced no usable seed: flowering and maturation were unsuccessful in these windows.

Germination rate also differed highly significantly ($P = .000$). Seed lots T1, T2 and T5 reached 46.3%. T3 stood at 36.3%, T6 at 30.3% and T4 at 26.3%. Winnowing reduced the weight of crude lots by about 50%, which underlines the importance of cleaning when estimating the usable seed yield.

Table 3. Seed yields and germination rate of *P. maximum* cv. C1 according to sowing date (mean ± standard deviation)

Treatment	Crude seed (kg/ha)	Cleaned seed (kg/ha)	Germination (%)
T1	210,0 ± 110,5 bc	121,1 ± 82,8 bc	46,3 ± 6,8 a
T2	358,9 ± 198,3 c	198,9 ± 116,9 c	46,3 ± 23,2 a
T3	295,5 ± 248,2 c	151,1 ± 123,9 c	36,3 ± 11,0 a
T4	85,5 ± 74,1 ab	34,4 ± 29,9 ab	26,3 ± 8,4 ab
T5	80,0 ± 80,0 ab	37,8 ± 36,7 ab	46,3 ± 16,5 a
T6	95,5 ± 62,9 ab	41,1 ± 29,1 ab	30,3 ± 16,5 ab
T7	0	0	0
T8	0	0	0
T9	0	0	0
T10	0	0	0

Different letters indicate a significant difference (LSD, $P < .05$). Treatment key: T1 = 15 May; T2 = 30 May; T3 = 15 June; T4 = 30 June; T5 = 15 July; T6 = 30 July; T7 = 15 August; T8 = 30 August; T9 = 15 September; T10 = 30 September.

The results show that sowing date is not a mere calendar adjustment: it determines the coupling between the plant cycle and the two rainy seasons of central Côte d'Ivoire. Late-June and mid-July sowings coincide with the end of the long rainy season. They still benefit from residual moisture sufficient to activate axillary buds and support elongation, hence the maximum tillering observed (77.9 to 82.7 tillers). This interpretation agrees with the observations of Skerman and Riveros (1990) on the role of water supply in the tillering of tropical grasses.

Sowing on 15 September (T9) occurs at the start of the short rainy season. It produced both the greatest height and, above all, the highest dry biomass (8,410 kg DM/ha/semester; 78% DM). This semester value lies within the broad range reported for Guinea grass under favourable water and fertility, which commonly reaches 9–15 t DM/ha across sites (César *et al.*, 1999; Wekgari & Dereba, 2025). The high dry-matter content, relative to younger cuts, is consistent with a more advanced stage of growth at the September harvest. The difference from older local figures is likely explained by the stage at which plants were cut, the water regime at the end of the cycle, and more thorough drying of the September samples. Conversely, late-July and August sowings expose young plants to the short dry spell: growth slows, consistent with the effects of a temporary water deficit described by Wilson (1975). Sowing on 30 September meets the long dry season almost immediately; height and tillering collapse.

The decoupling between biomass production and seed production is the most operational result of the trial. T9, the best forage treatment, yielded no seed. T2 and T3, less spectacular in DM, provided 151 to 199 kg/ha of cleaned seed, with 36 to 46% germination. This level is of the same order of magnitude as earlier collection references for cv. C1 (ORSTOM, 1982), although more recent local seed-yield data remain scarce. Late sowings do not reach the reproductive stage before the rains stop: flowering and grain filling require continuous water availability that August and September no longer guarantee (Cook *et al.*, 2005; Ouattara *et al.*, 2018). Two practical implications follow. For a farmer whose objective is animal load, mid-September sowing is the most profitable in biomass and TLU. For a multiplication station or a seed producer, the late-May to mid-June window is the only one that combines seed yield and acceptable germinative capacity. The same sward therefore cannot, in this climate, maximize forage and seed at once: the calendar must be chosen according to the purpose. The high standard deviations of some treatments (notably T2, T8 and T9 for biomass) nevertheless recall the sensitivity of the trial to within-plot heterogeneity and argue for a multi-year repetition before locking in a regional recommendation.

4. Conclusion

In Bouaké, under the single season studied, the sowing date of *Panicum maximum* cv. C1 significantly controlled growth, biomass, carrying capacity and seed quality. Two provisional windows emerge: (i) 30 May to 15 June to produce seed (up to 199 kg/ha of cleaned seed and 46% germination); (ii) 15 September to maximize dry biomass (8,410 kg DM/ha/semester) and animal load. August and late-September sowings should be avoided for seed, and late-July–August sowings remained poor for forage. These benchmarks are a simple lever for forage intensification under a transitional climate, but they come from one site and one year and should not yet be treated as a regional recommendation. Complementary multi-year trials should assess in vivo digestibility and production cost, in order to translate these agronomic performances into a benefit for the farmer.

5. Limitations

The experiment was conducted at one site during a single production cycle, and several treatments showed high variability. Carrying capacity was estimated from dry-matter yield using a fixed daily intake and allowable offtake coefficient rather than through direct grazing evaluation. The findings therefore reflect the tested conditions and require multi-year confirmation before broader regional extrapolation. The study focused on agronomic performance; *in vivo* digestibility and production costs were not evaluated and remain relevant for translating the observed responses into farm-level value.

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Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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