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*Research Article*

# Response of pearl millet [*Pennisetum glaucum* (L.) R. Br.] varieties to sowing date at N'Dounga, Niger Republic

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## Abstract

Appropriate sowing date is an essential and fundamental aspect of crop production that leads to high yield and economic returns for the farmers. Field experiments were conducted at N'Dounga Research Station during the 2016 and 2017 rainy seasons to determine the effect of sowing windows on the growth and yield of millet varieties in Niger Republic. Four varieties (HKP, ZATIB, CIVT, and H80-10 GR) were used in the experiment, and two sowing dates (late June and mid-July) were factorially combined (2 x 4) and laid in split-plot designs with three replications. Sowing dates were assigned to the main plots and varieties to the subplots. Data on plant height, panicle length, panicle diameter, 50% flowering and physiological maturity, harvest index, panicle number, and grain yield were collected, and JMP software was used to analyze variance. Significantly different means were separated using the Student-Newman-Keuls Test (SNK) at $p<0.05$. Results revealed that higher growth, grain yield, and yield components were recorded from ZATIB variety compared to all other varieties. Plants sown in late June performed better than those sown in mid-July. A Significant effect was observed on above-ground biomass, plant height, and grain yields. ZATIB variety sown in late June produced a significantly higher grain yield with 1257.85kg/ha.

## 1. Introduction

Climatic hazards and repeated drought periods, especially in recent years, have led to a recurrence of the food crisis in Niger Republic. Pearl millet is a major staple food crop because of its capacity for adaptation and toughness to the severe climatic conditions that define the Sahel area of Niger. It can be cultivated in locations where other cereal crops like maize and sorghum cannot [1]. Agriculture in Niger is subsistence, low inputs, less mechanized, and sensitive to changes in climate factors, and hence the country is vulnerable to food insecurity. Resilient agriculture practices should be formulated to improve productivity and reduce food insecurity. Crop production is limited by climate change and variability, water stress, poor soil fertility, lack of access to improved seeds/varieties, inputs, downy mildiou disease, and high dependence on rainfed agriculture, as well as credit and markets [2]. Due to their great resistance to the effects of climate change, acceptable productivity, and nutritional content, pearl millets, in particular, are becoming increasingly popular. Pearl millet is receiving attention because it is gluten-free and recommended for its health benefits. A major constraint of millet production in Niger is often linked to erratic rainfall patterns leading to water stress at some critical crop growth stages that cause low yield [3]. This poses a significant threat to food production in Niger. In addition, the low inherent fertility of the soil, lack of use of improved varieties and fertilizers as well as the use of inappropriate planting dates contribute to the low yield of pearl millet in Niger compared to other regions in the world [4]. Adopting high-yielding crop varieties and climate-smart practices offers an alternative solution to increasing crop production in highly variable weather [5]. Appropriate decision-making, such as choosing the ideal sowing date, is essential not only to maximize crop yield and quality but also to reduce the probability of crop stand failure, eliminate labor costs, and reduce overall production costs [6]. An efficient technique for coping with climatic change is manipulating the sowing date to boost productivity [7]. Because it directly impacts the challenges posed by climate change to arid and semi-arid environments, the sowing date adjustment is essential [8].

Identifying suitable varieties and appropriate sowing dates is an effective way to deal with the issues of climate change, which is seriously threatening the food security in Niger Republic. Therefore, the objective of this study was to investigate the response of pearl millet varieties to planting windows and determine the most suitable sowing date and millet variety for the study area.

## 2. Materials and methods

*2.1 Experimental site*

The field experiments were conducted at N'Dounga Research station located on (2°18′ 28″ E 13° 15′ 00″ N) South-West of Niamey, the capital city of Niger Republic. The mean annual precipitation at the station is around 500 mm, with a long dry season from October to May. The annual temperature is approximately 28°C. The natural vegetation type in the area is dry savannah with shrubby trees, dominated by *Guiera senegalensis* J.F. Gmel., *Piliiostigma reticulum* (DC.) Hochst. and *Faidherbia albida* (Del.) Chev.

*2.2 Treatments and experimental design*

The experimental design was a split plot with three replications having two sowing dates, 25th June (late June) and 13th July (mid-July) in 2016 and 26th June (late June) and 19 July (mid-July) in 2017, and four varieties of pearl millet (HKP, ZATIB, CIVT, and H80-10 GR). The sowing date was allocated to the main plot, while the variety was to the subplot. The size of the whole plot was 60 m2, with six (6) rows, each with a distance of one meter and a length of ten meters.

*2.3 Data collection*

Data were collected from a net plot of two inner-most rows (10 x 2 m), i.e., 20 $m^2$. The other outside rows were used as a border to minimize the impact of adjacent treatment or factors outside the experimental area—an alley of 2 m between the replications. Five seeds were sown in each hole and covered. The recommended agronomic practices of pearl millet were carried out accordingly. The following data were collected:

a) Plant height: this was measured from the ground to the base of the panicle at physiological maturity after selecting five plants randomly from the net plot.
b) Panicle length, which was measured using a calibrated ruler at harvest.
c) Days to 50 % flowering: the actual days from sowing to when 50% flowering in each plot was noted and recorded.
d) Days to physiological maturity: the number of days from the sowing date to when 95% of the panicle in the net plot reached physiological maturity was counted and recorded.
e) Above-ground biomass: Above-ground biomass was determined at physiological maturity. All the plants in the net plots were harvested, and weight was recorded. These were chopped, weighed, and oven-dried at 70°C for 48 hours.
f) Panicle diameter was measured using a vernier caliper in the middle of the panicle.



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g) Number of panicles: this was determined by counting the number of panicles per net plot.

h) Harvest index: the total dry matter produced by a crop is known as biological yield and a fraction of the biological yield which is useful for human beings is known as economic yield. Harvest index may be defined as the ratio between economic yield and biological yield. It is generally expressed as fraction and sometimes as a percentage.

$$Harvest\ Index\ (H.I) = \frac{Economic\ Yield}{Biological\ Yield} = \frac{Dry\ Grain\ Yield}{Total\ dry\ weight}$$

i) The grain yield from each net plot was carefully determined by weighting all threshed clean grain and converted to kilogram per hectare using the formula:

Grain yields per/ha (kg)

$$= \frac{Grain\ \ yield\ /net\ plot\ (Kg)X10000}{Net\ plot\ area\ (m^2)}$$

*2.4 Data analysis*

All the data collected from the field were subjected to analysis of variance using the JMP software. The mean differences were separated at 5 % level of probability.

## 3. Results

Table 1 shows the effects of sowing windows on the plant height and above-ground biomass of millet varieties in 2016 and 2017. Significant differences were observed in plant height between sowing windows in 2017 ($p<0.02$). However, there is no significant difference between the sowing dates in 2016.

Sowing in late June produced significantly taller plants than the mid-July sowing in both instances. No significant differences in plant height were observed between the four varieties in 2016 despite CIVT having the highest mean value. The table also shows that there is a significant difference between the varieties ($p<0.03$) involved in the experiment of 2017, where the plants of the variety ZATIB gave the highest average of (2.32 m) but on an equal level with all the other varieties, except for HKP which yielded significantly shorter plants (2.09 m).

The interaction of sowing window and variety was not significant on plant height in both years. Similar trends were observed for above-ground biomass (Table 1), where sowing in late June led to the production of significantly higher above-ground biomass than delaying sowing ($p<0.04$) to Mid-July in 2016 but not in 2017, where non-significant differences were observed. Concerning varieties, the results showed no significant differences across the two years of experimentation. The highest biomass was found with the variety H80-10 GR, averaging 6796.20 kg and 7470 kg in 2016 and 2017, respectively. However, the lowest biomass was found with the variety HKP averaging 6124.5 kg and 6243.3 kg in 2026 and 2017 respectively. The interaction between sowing date and variety on biomass was not statistically significant in each of the two years.

**Table 1.** Effect of sowing date on plant height and above ground biomass of millet varieties in 2016 and 2017 rainy seasons at N'Dounga

| Treatment | Plant Height (m) | | Biomass (kg ha$^{-1}$) | |
|---|---|---|---|---|
| | **2016** | **2017** | **2016** | **2017** |
| *Sowing Date(S)* | | | | |
| Late June | 2.5a | 2.3a | 7519a | 7044.7a |
| Mid-July | 2.2a | 2.1b | 5546b | 6661.9a |
| p<F | 0.12 | 0.02 | 0.04 | 0.38 |
| LSD 5% | 0.5 | 0.08 | 1876.1 | 1493 |
| *Variety (V)* | | | | |
| CIVT | 2.42a | 2.25a | 6727.3a | 6898.3a |
| H80-10 GR | 2.39a | 2.28a | 6796.2a | 7470a |
| HKP | 2.30a | 2.09b | 6124.5a | 6243.3a |
| ZATIB | 2.29a | 2.3a | 6482.7a | 6800.6a |
| p<F | 0.54 | 0.03 | 0.50 | 0.25 |
| LSD 5% | 0.23 | 0.15 | 1026 | 1239.9 |
| *Interaction* | | | | |
| S × V | 0.91 | 0.41 | 0.42 | 0.08 |

Mean followed by the same letter (s) within a treatment group are not significantly different at 5% level of probability using Student Newman Keuls (SNK) Test.

Table 2 shows the effect of planting date and variety on panicle length, but the June planting date produced longer than mid-July. As for variety, non-significant differences in panicle length were observed in both years. Results on panicle diameter are shown in Table 2. It showed that sowing dates affected yield ($p<0.03$) in 2016, with panicle diameter in late June giving a higher average of (27.77mm) while the mid-July sowing date registered (21.76 mm).



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No significant difference was observed in 2017. The interaction between the sowing date and variety did not reveal any significance. Regarding days to flowering and physiological maturity, the sowing date did not significantly affect these traits in 2016 and 2017. Similarly, no significant differences were observed among the variety across the years. All the interactions between the sowing date and variety were insignificant on both parameters (days to 50 % flowering and maturity) (Table 3).

**Table 2.** Effect of sowing windows on panicle length (cm) and panicle diameter (cm) of millet varieties in 2016 and 2017 rainy seasons at N'Dounga (on-station)

| Treatment | Panicle Length (cm) | | Panicle Diameter (mm) | |
|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 |
| *Sowing Date (S)* | | | | |
| Late June | 67.09a | 47.7a | 27.77a | 25.54a |
| Mid July | 61a | 62.6a | 21.76b | 25.20a |
| p<F | 0.09 | 0.09 | 0.03 | 0.60 |
| LSD 5% | 8.08 | 3.03 | 4.59 | 2.34 |
| *Variety (V)* | | | | |
| CIVT | 66.23a | 4.27a | 24.83a | 24.41a |
| H80-10 GR | 64.83a | 4.83a | 24.94a | 26.30a |
| HKP | 61.4a | 2.23a | 24.79a | 23.25a |
| ZATIB | 67.75a | 4.55a | 24.49a | 26.53a |
| p<F | 0.07 | 0.18 | 0.96 | 0.06 |
| LSD | 5.84 | 3.81 | 2.02 | 2.63 |
| *Interaction* | | | | |
| S × V | 0.47 | 0.48 | 0.37 | 0.70 |

Mean followed by the same letter (s) within a treatment group are not significantly different at 5% level of probability using Student Newman-Keuls (SNK) Test.

**Table 3.** Effect of sowing windows on days to 50% flowering and day to physiological maturity of millet varieties in 2016 and 2017 rainy seasons at N'Dounga

| Treatment | Days to 50% Flowering | | Days to Physiological Maturity | |
|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 |
| *Sowing Date (S)* | | | | |
| Late June | 66.66a | 71.25a | 92.91a | 93.08a |
| Mid-July | 67.75a | 65.41a | 91.41a | 91.41a |
| p<F | 0.78 | 0.07 | 0.48 | 0.28 |
| LSD 5% | 15.31 | 7.14 | 7.55 | 5.01 |
| *Variety (V)* | | | | |
| CIVT | 67.5a | 68.66a | 93.50a | 94.00ab |
| H80-10 GR | 68.16a | 69.16a | 92.83a | 92.16a |
| HKP | 66.16a | 68.33a | 91.83a | 91.50ac |
| ZATIB | 67.00a | 67.16a | 90.50a | 91.33a |
| P<F | 0.63 | 0.39 | 0.40 | 0.45 |
| LSD 5% | 3.14 | 2.50 | 3.89 | 3.89 |
| *Interaction* | | | | |
| S × V | 0.65 | 0.33 | 0.64 | 0.38 |

Mean followed by the same letter (s) within a treatment group are not significantly different at 5% level of probability using Student Newman Keuls (SNK) Test.

Results in Table 4 show the effect of the sowing date on harvest index, number of panicles, and grain yields. The results indicated no significant difference between the sowing date and harvest index in both years. However, the variety differed significantly in both years. In 2016, ZATIB recorded the highest harvest index, but it was at par with CIVT, while a non-significant difference was observed between H80-10 GR and HKF. In 2017, ZATIB had the highest harvest index but was at par with HKF, while H80-10 GR recorded the lowest harvest index but was at par with CIVT. There is no significant difference between HKF and CIVT, while a non-significant effect was observed due to variety in both years (Table 5). As shown in Table 5, there were no significant differences in the number of panicles due to factors and years. The sowing date had no significant effect on yield across the year; in 2016, the late June sowing date produced higher grain yield than the mid-July sowing date. Concerning the effect of variety on grain yield, a significant difference was observed in 2016, with the variety CIVT (1280 kg $ha^{-1}$) having the highest grain yield, followed by ZATIB and then H80-10 GR, whereas the variety HKP having the lowest (1000.8 kg $ha^{-1}$) grain yield. No statistical difference was found between the variety CIVT and H80 10 GR. Similarly, HKP and H80-GR were at par (Table 5). The interaction between sowing date and variety was only significant in 2016.

## 4. Discussion

Limited information on appropriate sowing dates results in yield losses in Niger Republic. Sowing millet at the right time is one of the effective ways of boosting economic yield, as it allows crops to reach their total potential yield; therefore, researching sowing dates is critical in determining grain yield potential. The sowing date had a significant effect on plant height in 2016. Late June planting produced taller plants than mid-July planting. This difference in plant height might be linked to the most conducive environment for plant growth throughout the growing season. The lower plant height may be explained by the lower temperature to which the crop


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**Table 4**. Effect of sowing windows on grain yield, harvest index and number of panicles of millet varieties in 2016 and 2017 rainy seasons at N'Dounga

| Treatments | Harvest Index | | Number of Panicles m$^{-2}$ | | Grain Yield kgha$^{-1}$ | |
|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| *Sowing Date(S)* | | | | | | |
| Late June | 0.16a | 0.17a | 4.2a | 3.72a | 1216.30a | 1161a |
| Mid-July | 0.31a | 0.17a | 2.97a | 4.72a | 1103.60a | 1141.80a |
| p<F | 0.29 | 0.31 | 0.02 | 0.17 | 0.43 | 0.31 |
| LSD | 0.45 | 0.01 | 0.84 | 0.77 | 503.85 | 225.03 |
| *Variety (V)* | | | | | | |
| CIVT | 0.19a | 0.17a | 3.80a | 3.95a | 1280.80a | 1190.40a |
| H80-10 GR | 0.16a | 0.15a | 3.50a | 3.73a | 1092.00b | 1119.90a |
| HKP | 0.38a | 0.18a | 3.50a | 3.99a | 1000.80b | 1095.00a |
| ZATIB | 0.19a | 0.18a | 350a | 3.97a | 1201.30a | 1201.30a |
| P<F | 0.50 | 0.79 | 0.76 | 0.74 | 0.0007 | 0.79 |
| LSD | 0.34 | 0.08 | 0.74 | 0.57 | 122.06 | 424.07 |
| *Interaction* | | | | | | |
| S×V | 0.47 | 0.84 | 0.43 | 0.004 | 0.001 | 0.84 |

*=significant at 5%, **=highly significant and NS= not significant, Mean followed by the same letter (s) within a treatment group are not significantly different at 5% level of probability using Student Newman Keuls (SNK) Test.

**Table 5**. Interaction of sowing date and varieties on the grain yields in 2016

| Sowing Windows | Varieties | | | |
|---|---|---|---|---|
| | CIVT | H80-10 GR | HKP | ZATIB |
| Late June | 1061.52b | 1037.10bc | 1034.18bc | 1257.85a |
| Mid-July | 895.35c | 1033.18bc | 917.18bc | 952.35bc |
| SE± | 53.53 | | | |

Mean followed by the same letter (s) within a treatment group are not significantly different at 5% level of probability using Student Newman Keuls (SNK) Test.

was subjected after emergence. The reduction of days to flowering was observed when sowing was delayed in 2016. This trend was also noticed in 2016 and 2017 on physiological maturity. The significant yield and yield components differences between the sowing dates could be because early sowing enabled the crop to receive well-distributed rainfall uniformly, which enabled the crops to cover their needs during the flowering stage that requires more moisture. This finding supports the report of [9, 10]. In another report, it is apparent that early sowing without dry spells performed better than late sowing, and it was also observed that dates of sowing significantly influenced the grain yield of pearl millet during all the years of experimentation and on a pooled basis [11]. It was observed in this study that delays in sowing led to a reduction of grain yield, and this corroborates with the finding of [12], who found that delayed sowing delays the crop phenological development, thereby causing a significant reduction in crop yields [13,14] also reported similar observation under delayed sowing on sorghum and mustard, respectively. Above-ground biomass was significantly influenced by variation in sowing dates, where early sowing resulted in the highest above-ground biomass in 2016. The differences in above-ground biomass may be that the late sowing dates experienced more water deficit conditions as the rains ended early. This finding is in line with the report of [15], who noted a considerable reduction in yield and yield components of maize when sowing was delayed in Northern Nigeria. Similar yield reductions due to delayed planting have been reported by many [17]. The significantly higher height produced by ZATIB compared to the other varieties could be due to the genetic make-up of ZATIB being more adaptable to the Sudan agro-ecological zone. Similar results were reported by [18], who reported that this variety has taller plants in Sudan. The results from both experiments showed variations in the number of days to 50% flowering among the varieties. It was found that the CIVT variety reached 50% flowering earlier compared to others. This may be explained by its ability to tiller faster than other varieties. ZATIB produced the highest grain yields among the varieties. This might be due to the variety's adaptability to the soil and weather conditions of the experimental locations. Similar results were found by [18], who reported


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that the yield of pearl millet varies among varieties.

## 5. Conclusions

The results of this study showed that sowing dates had a significant effect on growth parameters and yield of pearl millet at N'Dounga in Niger Republic. Late June sowing dates produced significantly higher grain yield compared to mid-July sowing dates. The ZATIB variety achieved the highest grain yield compared to the other varieties tested. Based on the findings of this study, it can be anticipated that late June is the best sowing date for farmers to adopt when using the promising cultivar (ZATIB) for maximizing yield of pearl millet at N'Dounga in Niger Republic.

## Authors' contributions

Conceptualization, methodology, investigation, data acquisition and curation, writing – original draft and editing, A.M.L.M.; Conceptualization, methodology, writing – review & editing, B.M.A.; Supervision, conceptualization, methodology– review & editing, J.M.J.; Writing– review & editing, M.G.; Formal analysis, writing – review & editing, S.U.A.; Conceptualization, methodology, writing – review & editing, A.A.

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## Availability of data and materials

All data will be made available on request according to the journal policy

## Conflicts 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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