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Effect of Photoperiod on the Germination and Seedling Development of Some (Acha) *Digitaria* Species

Davou D. Nyam[a*], Alex E. Angyu[b], Kyenpiya E. Deshi[c], Sukat N. Dawang[d], Habila Susinya[e], Onyekwere P. Ifenkwe[f]

[a,c,d,e,f]*Department of Plant Science and Technology, University of Jos, Jos Nigeria*

[b]*Department of Biological Sciences, Taraba state University, Jalingo, Nigeria*

[a]*Email: ddavounyam@gmail.com*

Abstract

A glass house study was conducted at the Botanical garden, University of Jos, Jos Nigeria to study the effects of photoperiod on germination and seedling development of three *Digitaria* species (*D. exilis, D. barbinodis*, and *D. iburua*) using the Completely Randomized Design (CRD).The three species were subjected to photoperiods of 6, 8, 10, and 12hrs for 21 days. Results show that *D. iburua* had 30% germination while *D. exilis* and *D. barbinodis* had 80% germination irrespective of photoperiod; plant height, leaf length, number of nodes, length of internodes, leaf width, number of leaves, root length and number of rootlets were highest at 12hr photoperiod. Plant height, length of internodes and leaf length were highest in *D. barbinodis* at 10hr photoperiod, while number of nodes, stem girth, root length and number of rootlets were highest at 12hr photoperiod. Plant height, leaf width and number of rootlets were highest in *D. iburua* at 10hr photoperiod while number of leaves, length of internodes, root length and stem girth were highest at 12hr photoperiod. Significant photoperiods x species interaction were observed in plant height, number of leaves, leaf length, leaf width and number of rootlets. Seedlings that were exposed to 6 or 8 hour photoperiod treatment were observed to have etiolated. The study showed that germination and seedling development in "Acha" (*Digitaria* Spp.) were affected by photoperiod.

Keywords: Photoperiod; Acha germination; seedling development.

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* Corresponding author.

1. Introduction

Digitaria species, also known as Acha, fonio fundi and kabuga, belongs to the family poaceae. It is an annual crop that grows to about 45-120 cm tall with tillers bearing linear glabrous leaves approximately 15cm long. *D. exilis* stapf, and *D. iburua* Stapf, have been cultivated as human cereal crops 1,2,3,4].They are cultivated for food in some restricted areas such as on the Jos Plateau and environs. *Digitaria exilis* cultivation is thought to date from 5000BC [5]. In spite of this, the cultivation is largely limited to the Northern Savannah belt of Nigeria and along that belt across the West African countries. The relative duration of light and darkness in a 24-hr cycle exerts great influence on plants, and even on animals [6]. Reference [7] recognized the effect of day light in leaf abscission (leaf fall), dormancy, hardness, leaf size pigmentation, germination and seedling development among others. Aside from controlling flowering and distribution of flowering plants, photoperiod influences the geographical distribution of woody plants by exerting control on the plants hardening, or acclimatizing to winter conditions. Reference [6] have reported the positive effect of photoperiods on the rooting of cuttings. This crop is cultivated in the northern guinea savannah. For this reason, it is important to study the effects of different light periods which should help give a range of the adaptability of the crop to different parts of the country, particularly the southern guinea savanna, so as to increase the production of the crop.

2. Materials and Methods

A trial was conducted at the Botanical Nursery of the Department of Plant Science and Technology, University of Jos, Jos, Plateau State, Nigeria. The accessions were obtained from the local farmers in Jos and its environments and placed in the herbarium/germlasm collections of the Department of Plant science and Technology, University of Jos. The accessions evaluated include Badama Piomo madu (*Digitaria exilis* Stapf), Nding Zawan (*Digitaria barbinodis* Henrard.) and Peng Madu (*Digitaria iburua* Stapf). The accessions refer to the names given in areas where they were originally collected. A Complete Randomized Design (CRD) with three replications was used. The area of the pot was 0.314m and the seeds were broadcast at the rate of 50 kg ha^{-1} equivalent of 1.54 g/pot in each of the 36 pots. The pots were initially filled with soil and watered, to allow for the soil to settle .The pots were then transferred from day light into the artificial darkness so created using black polythene at the following intervals: P_1 6hrs (6 am-12 noon); P_2 8hrs (6 am-2 pm) P_3 10hrs (6 am - 4 pm) and P_4 12hrs (6 am - 6 pm). No fertilizer was applied to the crops and watering was done once daily (in the morning). Field observation and data collection began immediately after germination of seeds until seedlings attained a period of 3 weeks (21days). Parameters assessed during the work period include Seedling height, number of leaves, leaf length, leaf width as well as length of internodes at 14 days after planting, stem girth, number of nodes, root length and number of rootlets. Natural phenomena such as cloud cover (variation in photoperiod intensity) may constitute some constraints in the expression of the assessed parameters.

3. Results

The accessions differed significantly in plant height, stem girth, length of internodes, number of leaves, leaf length, leaf width, number of rootlets and root length with respect to treatment and photoperiod. No such difference existed for number of nodes except with respect to replicates and species.

3.1. Seedling height

Digitaria iburua was tallest in height and this was significantly different from those of *D. exilis* and *D. barbinodis* .

3.2. Stem girth

Digitaria iburua had the widest stem girth and this was significantly different from those of *D. exilis* and *D. barbinodis*.

3.3. Number of nodes

D. exilis and *D. iburua* had their peaks in 10hr exposure period while *D. barbinodis* had its peak in 12hr exposure to light.

3.4. Number of leaves

D. barbinodis had the highest number of leaves per plant at 8hrs of exposure to light and lowest at 6hr, while *D. exilis* and *D. iburua* had their highest at 12hrs exposure and their lowest at 6hrs of exposure to day light.

3.5. Length of internodes

Digitaria exilis had the highest length of internodes followed by *D. barbinodis* and *D. iburua* in that order. Internode lengths were highest for *D. exilis* and *D. barbinodis* in 10hr exposure while the peak for *D.iburua* was at 12 hrs.

3.6. Leaf length

D. iburua had the highest leaf length and this varied significantly with *D. exilis* and *D. barbinodis.* There was significant photoperiod x species interaction with respect to leaf length.

3.7. Leaf width

D. barbinodis had the highest leaf width, followed by *D. exilis* and *D. iburua*. There was a significant photoperiod and species interaction with respect to leaf width.

3.8. Root length

D. barbinodis had the highest root length followed by *D. exilis* and then *D. iburua*. Interaction existed with respect to root length

3.9. Number of rootlets

D. barbinodis had the highest number of rootlets followed by *D. exilis* and then *D. iburua* in that order.

Table 1: Effect of photoperiod and species on seedling height (cm)

Species	Photoperiods (hrs)				mean	$LSD_{0.05}$
	6	8	10	12		
D. exilis	5.91	5.91	11.58	8.11	7.88	
D.barbinodis	6.63	7.56	9.32	7.15	7.66	0.16
D. iburua	6.79	6.77	10.79	7.81	8.03	
Mean	6.44	6.75	10.56	7.69		
$LSD_{0.05}$	1.16					

There was no significant difference between the species across all the photoperiods. The 10hr photoperiod resulted in the highest seedling height and the difference between it and other photoperiods was significant.

Table 2: Effect of photoperiod and species on stem girth (cm)

Species	Photoperiods (hrs)				mean	$LSD_{0.05}$
	6	8	10	12		
D. exilis	0.11	0.14	0.31	0.38	0.08	
D.barbinodis	0.21	0.24	0.32	0.39	0.01	0.16
D. iburua	0.17	0.2	0.37	0.39	0.09	
Mean	0.05	0.06	0.11	0.13		
$LSD_{0.05}$	1.19					

There was no significant difference between species .Also there was no significant difference between the different photoperiods.

Table 3: Effect of photoperiod and species on number of nodes

Species	Photoperiods (hrs)				mean	$LSD_{0.05}$
	6	8	10	12		
D. exilis	1.67	2.47	2.73	2.53	2.35	
D.barbinodis	1.8	2.67	2.53	2.93	2.48	
D. iburua	1	2.27	1.4	1	1.42	0.75
Mean	1.49	2.08	2.49	2.38		
$LSD_{0.05}$	0.78					

D. iburua had the least number of nodes and the difference was significantly different with those of *D. exilis* and *D. barbinodis.*

Table 4: Effect of photoperiod and species on length of internode (cm)

Species	Photoperiods (hrs)				mean	$LSD_{0.05}$
	6	8	10	12		
D. exilis	0.66	0.71	2.02	0.79	1.05	
D.barbinodis	0.64	0.83	1.22	0.79	0.87	
D. iburua	0.59	0.72	0.53	1.00	0.56	0.7
Mean	0.57	0.75	1.23	0.86		
$LSD_{0.05}$	0.09					

There was no significant difference between species across all the photoperiods. 10hr photoperiod resulted in the longest internode length and this was significantly different from all other photoperiods.

Table 5: Effect of photoperiod and species on number of leaves per plant

Species	Photoperiods (hrs)				mean	$LSD_{0.05}$
	6	8	10	12		
D. exilis	3.8	4.2	4.13	4.0	4.03	
D.barbinodis	4.0	4.2	4.0	4.47	4.17	
D. iburua	3.3	3.8	3.6	4.27	3.75	0.26
Mean	3.71	4.07	3.91	4.24		
$LSD_{0.05}$	0.10					

D. iburua had the least mean number of leaves per plant and those of *D. exilis* and *D. barbinodis* was significant. Also, 12hr photoperiod resulted in the largest number of leaves per plant and this was significantly higher than all other photoperiods. The least number of leaves occurred at the 6hr photoperiod. In *D. exilis*, largest number of leaves occurred at the 8hr photoperiod whereas in *D. barbinodis* and *D. iburua*, this occurred at the 12hr photoperiod.

Table 6: Effect of photoperiod and species on leaf length (cm)

Species	Photoperiods (hrs)				mean	$LSD_{0.05}$
	6	8	10	12		
D. exilis	5.59	6.13	7.79	6.03	6.39	
D.barbinodis	4.81	4.99	6.93	5.83	5.64	
D. iburua	5.65	5.92	7.09	7.03	6.42	0.70
Mean	5.35	5.68	7.27	6.30		
$LSD_{0.05}$	0.48					

The highest leaf length occurred at 10hr photoperiod and the difference with other photoperiods was significant .The least leaf length occurred at 6hr photoperiod followed by 8hrs. *D. exilis* were not significantly different but both were significantly different from *D. barbinodis* which had the shortest leaf length.

Table 7: Effect of photoperiod and species on root length (cm)

Species	Photoperiods (hrs)				mean	$LSD_{0.05}$
	6	8	10	12		
D. exilis	0.23	0.26	0.3	0.29	0.27	
D.barbinodis	0.28	0.33	0.32	0.3	0.31	
D. iburua	0.14	0.21	0.25	0.25	0.21	0.01
Mean	0.22	0.27	0.29	0.28		
$LSD_{0.05}$	0.01					

There was significant difference between 10hr photoperiod and all other photoperiods with respect to leaf width. The highest leaf width occurred at 10hr photoperiod followed by 12 and 8hrs. Six (6) hours had the least leaf width. There was no significant difference between the three species.

Table 8: Effect of photoperiod and species on root length (cm)

Species	Photoperiods (hrs)				mean	$LSD_{0.05}$
	6	8	10	12		
D. exilis	5.21	5.05	7.67	7.63	6.39	
D.barbinodis	6.21	7.16	7.23	7.28	6.97	
D. iburua	517	5.65	6.81	7.87	6.37	0.70
Mean	5.53	5.95	7.23	7.59		
$LSD_{0.05}$	0.63					

There was no significant difference between the species with respect to root length. The longest root length occurred at 12hr photoperiod although this was not significantly different from 10hr photoperiod but both were significantly different from 6hr photoperiod.

Table 9: Effect of photoperiod and species on number of rootlets

Species	Photoperiods (hrs)				mean	$LSD_{0.05}$
	6	8	10	12		
D. exilis	1.87	2.33	3.00	2.47	2.40	
D. barbinodis	2.53	2.60	2.47	2.73	2.58	
D. iburua	1.87	2.13	2.47	2.42	2.20	0.36
Mean	2.09	2.36	2.64	2.54		
$LSD_{0.05}$	0.39					

There was no significant difference between 12, 10 and 8hrs photoperiod but the three were significantly different from 6hr photoperiod which had the least number of rootlets. *D. barbinodis* had the largest number of rootlets followed by *D. exilis*. The difference between *D. barbinodis* and *D. iburua* was significant.

4. Discussion and conclusion

Although [8,9] suggested that stem elongation in response to long day is probably the most widely spread photoperiodic phenomenon, seedlings exposed to 10 hours daylight attained the highest height of 10.56 cm and was followed by those of 12 hours, with 7.69cm. This agrees with the work of [10] where Photoperiod was observed to significantly ($P \leq 0.001$) influence height and number of nodes of Tecoma seedlings when measured after 35 days of propagation. The duration of exposure to the different day lengths was however, short and it is not certain what would happen over an extended period. This was true for all three accessions used in this study. Reference [11] suggested that red light with high R/RF ratio applied as day–extension or night interruption (NI) suppressed stem elongation and inhibited lateral branching. The difference between day temperature (DT) and night temperature (NT) defined as DT-NT = DIF strongly influences plant height in a wide range of pot and bedding plants. Plants grown with a positive DIF (DT>NT) are taller at maturity than plants grown with a negative DIF (DT<NT). Seedlings with the widest stem girth were found to be under the longest photoperiodic treatment (12 hours), with the stem girth reducing as the photoperiodic exposures reduces although these differences were not significant. Reference [12] reported that the length of a leaf of *Oryzopsis maliacea* was maximal at a 12 hour photoperiod and declined sharply in both short (8 hours) and longer (up to 24hrs) ones . The number of nodes is a function of the genotype modified by temperature and photoperiod [13]. Since stem elongation has been reported by [8] to be a long day response, it should be expected that seedlings under long day should attain highest heights and hence have more number of nodes while those at 12 was significantly lower. Reference [14] showed that under the condition of short photoperiod, number of nodes of main stem increased in plants with strong photoperiodic sensitivity. Internode length in 'Dollar Princess' fuchsia has been reported to be affected by photoperiod and temperature. Internode length, averaged over all treatments, was 142% greater on plants grown under long day (LD) than on plants grown under short day (SD) [15]. Photoperiod has been reported to control bud dormancy in seedlings [16]. For example *Betula pubescens* transferred to short days ceased growth and formed resting buds, hence reduced internode length whereas seedlings maintained under longer days continue to grow actively for months, hence longer nodes. Internodes length increased up to 10hr photoperiod and declined as the photoperiod increased to 12 hrs. Since longer photoperiods beyond 12hrs were not used in this study, it is difficult to know if longer photoperiods would not have led to longer internodes. Species had no influence on the length of internode and thus suggest that environmental variation had more influence in the expression of internode length. Reference [12] reported that the total leaf number in *Oryzopsis miliacea* was initially higher in longer day length but eventually became equal in all inductive photoperiods. In this study, the species varied significantly in leaf number across all photoperiods. The 12hr photoperiod resulted in the largest number of leaves per plant in all photoperiods. Since there was significant interaction between species and photoperiods, there is an indication that the different species responded differently to the different photoperiods. Reference [17] reported that leaf formation in the apical meristem emerge and unfold as well as shape and size of the lamina (Leaf width) depends on the temperature, light intensity, and day length under which the plant is grown. There was a significant photoperiod

and species interaction with respect to leaf width.

Rooting of cuttings have been reported to be affected by long days, both when applied to the cutting itself and when applied to the mother plant from which the cutting was taken [6]. There was interaction between species and photoperiod implying that photoperiod played a significant role in the root length in conjunction with the genotype of the species used. Seedlings exposed to longer photoperiodic treatments (10 and 12 hours) had higher root length compared with those of shorter photoperiods. The growth of lateral root is stimulated by far red light and inhibited by red light. Reference [18] reported "Thompson hypothesis" and stated that light accelerates all phases of the developmental sequence from cell division through elongation to maturation but it seemed not to be true for number of rootlets as roots and rootlets are underground structures of the seedlings; seedlings with longest day light exposure of 12 hours had fewer rootlets than those of 10hrs which was 2hrs less. This might be attributed to the phytochrome since lateral roots are stimulated by far red light and inhibited by red light.

5. Conclusion

Considering the level of significance in the results, it is clear that photoperiod had far less, if any effect on seed germination of *Digitaria* and grossly affected the development of the seedling.

6. Recommendation

Further investigation lasting over a prolonged period and extended photoperiod may be necessary to ascertain the full effects of photoperiod on the growth and development of the crop.

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