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# INVESTIGATING THE IMPACT OF PHOTOPERIODISM ON THE GROWTH AND YIELD OF *Vigna unguiculata* GROWN WITH BIOFERTILIZER AND INORGANIC FERTILIZER IN EARLY AND LATE RAINY SEASONS

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## ABSTRACT
*Cowpea (Vigna unguiculata) is a vital legume crop in many tropical regions, including Nigeria. Photoperiodism, which is the response of plants to the length of light and darkness, significantly affects cowpea growth and yield and plays a crucial role in regulating plant growth and development. This study investigated the impact of photoperiodism on the growth and yield of Vigna unguiculata (cowpea) grown with a combination of biofertilizer and inorganic fertilizer (single superphosphate) in early and late rainy seasons. The experiment was conducted in a screenhouse, where the pots were arranged in a completely randomized block design with three replicates, two natural photoperiod treatments (10, and 14 hours of light), two fertilizer treatments (biofertilizer + inorganic fertilizer, and control) and three varieties of cowpeas (IT89KD-391, ITK-593-1-1, and IT90K-82-2). The results showed that different photoperiods significantly affected cowpea growth and yield. The shorter photoperiod of 10 hours increased flowering, pod formation, and grain yield, while the longer photoperiod of 14 hours promoted vegetative growth. There was much variation in plant height between experiments 1 (14hrs of photoperiod treatment or early rainy season) and experiment 2 (10hrs of photoperiod treatment or late rainy season). Cowpea varieties in experiment 1 grew vegetatively only, without fruiting while in experiment 2, they flowered and fruited. Maximum height recorded in experiment 1 was 149.57cm ($C_1B_2I_2$). The least height was 62.40m ($C_1B_1I_2$). In experiment 2, the maximum height recorded was 29.56m ($C_2B_2I_1$) while the lowest was 17.67 ($C_2B_1I_2$). Plants grown in the late rainy season with shorter photoperiod had higher yield parameters while there was no yield in the plants grown in the early rainy season. The combination of biofertilizer and inorganic fertilizer enhanced cowpea growth and yield, particularly under the shorter photoperiod. The optimal photoperiod for cowpea growth and yield was found to be 10 hours, with a fertilizer combination of biofertilizer and inorganic fertilizer. This study highlights the importance of photoperiodism in regulating cowpea growth and yield and demonstrates the potential of using biofertilizer and inorganic fertilizer combinations to optimize crop production in early and late rainy seasons. Farmers can use this information to plan their planting schedules and choose the most suitable fertilizer combination for their region.*

**KEYWORDS:** *Photoperiodism, Vigna unguiculata, Biofertilizer, Inorganic fertilizer Early and late rainy seasons*

## INTRODUCTION

Cowpea (*Vigna unguiculata*) is a vital legume crop in many tropical regions, including Nigeria. It is an excellent source of protein, fiber, and minerals, making it a staple food for millions of people. Cowpea is also an important crop for sustainable agriculture due to its ability to fix atmospheric nitrogen, reducing the need for synthetic fertilizers (Okeleye *et al*., 2020). In Nigeria, cowpea is a staple crop, and its production is crucial for food security and sustainable agriculture (Adebisi *et al*., 2020). However, cowpea production is often limited by environmental factors, including photoperiodism.

Photoperiodism, the response of plants to the length of light and darkness, plays a critical role in regulating plant growth and development (Thomas,2018). Photoperiodism significantly affects cowpea growth, particularly in the following aspects: Longer photoperiods (12-14 hours) promote vegetative growth, leading to taller plants with more leaves (Singh *et al*., 2020) whereas shorter photoperiods (10-12 hours) induce flowering and pod formation, resulting in a shorter vegetative phase (Okeleye *et al*., 2020). Shorter photoperiods (10-12 hours) can lead to increased grain yield, while longer photoperiods (12-14 hours) can reduce grain yield (Singh *et al*., 2020).

Photoperiodism affects pod length and width in cowpea. Shorter photoperiods can lead to longer and wider pods (Okeleye *et al*., 2020). It influences seed weight and size in cowpea. Shorter photoperiods can lead to heavier and larger seeds (Adebisi *et al*., 2020). Photoperiodism affects the harvest index in cowpea. Shorter photoperiods can lead to a higher harvest index, indicating more efficient partitioning of dry matter to grain (Kumar *et al*., 2019).

The combination of biofertilizer and inorganic fertilizer can enhance cowpea growth and yield, particularly under shorter photoperiods (Okeleye *et al*., 2020). Biofertilizers, such as Rhizobium inoculants, have been shown to increase cowpea productivity by enhancing nodulation rates, nitrogen fixation, and phosphorus uptake (Singh *et al*., 2018). Inorganic fertilizers, such as SSP and NPK, provide essential nutrients for plant growth but can have negative environmental impacts when used excessively (Adebisi *et al.*, 2020). The combination of biofertilizer and inorganic fertilizer has been reported to have synergistic effects on cowpea growth and yield (Okeleye *et al*., 2020).

However, the impact of photoperiodism on cowpea growth and yield when treated with this fertilizer combination is not well understood. This study aims to investigate the impact of photoperiodism on the growth and yield of *Vigna unguiculata* grown with biofertilizer and inorganic fertilizer in early and late rainy seasons.

The specific objectives are:

1. To evaluate the effect of photoperiodism on cowpea growth and yield in early and late rainy seasons.
2. To assess the impact of the combination of biofertilizer and inorganic fertilizer on cowpea growth and yield.
3. To investigate the interaction between photoperiodism and fertilizer combination on cowpea growth and yield.

The findings will help farmers and agricultural practitioners optimize cowpea production in tropical regions. Understanding the impact of photoperiodism on cowpea growth and yield is essential for optimizing crop production in tropical regions.

***Study Area***

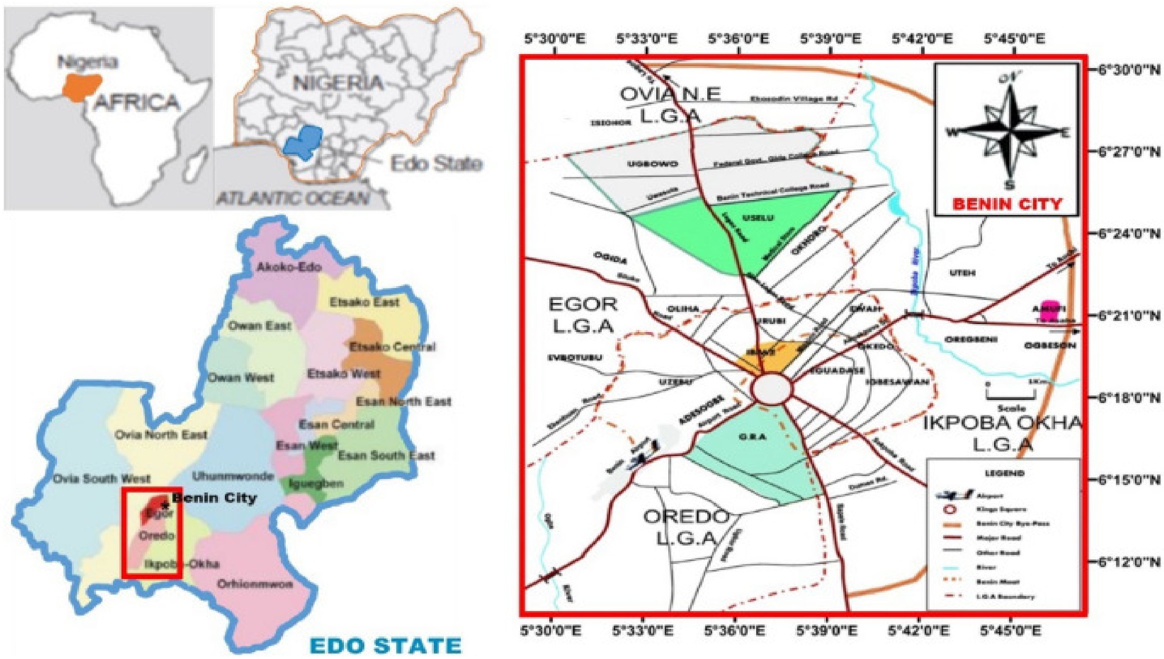
The experiment was carried out during the periods of May - July and September - November 2019, at the Crop Science Laboratory of the Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria. Benin City, the capital of Edo State in southern Nigeria, is the fourth largest city in Nigeria (West Africa) and transverses Oredo, Ikpoba-Okha, Egor and Ovia North-East local government areas (Omuta, 2020). It is situated approximately 40 km north of the Benin river, between latitudes 6° 12′–6° 27′ N and longitudes 5° 29′–5° 45′ E (Adebayo, 2020). The city covers a fairly flat land area of 1125 km and is 8.5 km above sea level (Ojo, 2022).

Benin City has a hot and humid climate, characterized by high temperatures and high humidity levels throughout the year. The city experiences two main seasons: a wet season from April to November and a dry season from December to March (Adeloye, and Silva (2020). The average daily temperature is around 28°C in the dry season and 24°C in the wet season (Adeloye, and Silva (2020). A study on climate change in Benin City found that the average temperature has shown a significant trend of increase over the years, with a corresponding increase in rainfall (Floyd *et al*., 2016)

The vegetation in Benin City is predominantly tropical rainforest, with some areas of derived savanna. The riverine areas of Edo State have mainly mangrove swamp vegetation, while the northern fringes of the Esan Plateau have savannah vegetation (Aigbedion-Atalor, and Okhimamhe, 2020) The city's vegetation has been significantly altered due to urbanization and agricultural activities.

Benin City has undergone significant land use changes over the years, driven by urbanization and population growth. The city's land use can be broadly categorized into:

- Urban areas: The city's urban areas are characterized by high-density residential and commercial development.
- Agricultural areas: The surrounding areas are used for agricultural purposes, including crop farming and livestock production.
- Forest areas: Some areas of the city still retain their natural forest cover, including the Okomu National Park (Afolayan *et al*., 2020).
- Wetlands: The city has several wetlands, including the Ikpoba River and its tributaries.




Map of Benin City, Nigeria (adapted from Edo State Ministry of Lands and Survey)

## MATERIALS AND METHODS

### *Seed collection*

Three certified Cowpea varieties, IT89KD-391, IT99K-593-1-1 and IT90K-82-2, were obtained from the germplasma unit at the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria.

### *Biofertilizer*

Phosphate-solubilizing bacteria (PSB) were isolated from the rhizosphere soil of *Vigna unguiculata* and multiplied in a laboratory. Three (3) kg each of the cured PSB biofertilizers stored in polythene bags was incorporated in the soil at the time of sowing. Equal number (3) of seeds was planted in each pot. One pot was kept as control in which there was no PSB biofertilizer applied. Pots were watered daily until harvest (Vincent, 1970), while Single Superphosphate (SSP) was used as the inorganic phosphate fertilizer source.

### *Soil Collection/ Pot Experiment*

Unsterilized soil samples were collected from the Capitol Research site of the Faculty of Agriculture, University of Benin with no history of Cowpea cultivation. The soil was collected with a shovel from 0 to 30cm, thoroughly mixed and dried in sunlight for 7days before dispensing into 20kg capacity buckets. (Sandhimita *et al*., 2022)

### *Experimental Design /Treatment*

The pots for the experiment were laid out in a randomized complete block design (RCBD) in the screen house, with three replications. Twenty-four (25) treatments comprising of:

Four isolates = $B_1$, $B_2$, $B_3$, $B_4$ = *E. hormaechei*, *E. cloacoa*, *Alkaligene* sp. and *Clostridium beijerinckii* (application of PSB at a rate of 10^8 CFU/g soil)

Two Inorganic fertilizer application rates = $1_1$ $1_2$. (Application of SSP at a rate of 20 kg and 30 kg).

Three seed varieties = $C_1$, $C_2$, $C_3$ (IT89KD-391, ITK-593-1-1, IT90K-82-2).
Natural photoperiod control: Plants were exposed to natural daylight hours, with no artificial lighting or shading.
Natural photoperiods in Nigeria between May - July (early rainy season)
May: 12 hours 30 minutes (sunrise: 6:10 am, sunset: 6:40 pm)
June: 12 hours 40 minutes (sunrise: 6:00 am, sunset: 6:40 pm)
July: 12 hours 30 minutes (sunrise: 6:10 am, sunset: 6:30 pm)
Natural photoperiods in Nigeria between September – November (late rainy season)
September: 12 hours 10 minutes (sunrise: 6:30 am, sunset: 6:40 pm)
October: 11 hours 50 minutes (sunrise: 6:40 am, sunset: 6:30 pm)
November: 11 hours 30 minutes (sunrise: 6:50 am, sunset: 6:20 pm)
Control = No fertilizer application.
(Sandhimita *et al*., 2022; NAFMAC, 2020.)

The irrigation of the plants continued all through growth of the plants and up to the harvesting of the pods. Weeds were removed when found growing in the pots.

***Physico-chemical Analysis of Soil Samples***

Collected soil samples for physico-chemical analysis were air dried at room temperature ($28 \pm 2^0C$) on a laboratory bench, crushed and sieved with a 2.0mm sieve. Physico-chemical analysis involved the determination of the following parameters: The total nitrogen was determined by Kjeldhal distillation method (Bremner,1996), available phosphorous by Olsen's method (Olsen, 1965), and available potassium by the ammonium acetate method (Black,1965). Organic matter was determined by Walkley-Black, (1942) pH (1:1 soil: water suspension) by Beckman Glass electrode pH meter and soil texture by the hydrometer method. EC was by the conductivity bridge meter (Black,1965), Ca and Mg by the flame atomic absorption spectrophotometry (Houba *et al*., 1986), CEC was by using the ammonium acetate method (Black,1965)

***Data Collection***

Data collected on growth variables were plant height, number of leaves, number of branches per plant, stem girth, and leaf area, shoot fresh weight and shoot dry weights, root fresh weight and root dry weights and root length, at intervals of 4weeks, for 12weeks. After fruiting, the test plants were assessed for yield components like number of pods per plant, pod fresh and dry weights, number of seeds per pod, and the number of nodules (Tennakoon, 2019; Osei-Yeboah, 2022 and Gupta *et al*., 2018).

***Data Analysis***

Data collected on growth and yield variables were subjected to analysis of variance using statistical analysis system software version 9.0. The treatment means were separated using LSD test at 0.05 probability. One-tailed t-test was conducted to compare the available phosphorus levels: Before sowing (pre-sowing) and after harvesting (post-harvest).

## RESULTS

***Effect of Cowpea Varieties, Biofertilizer, Inorganic Fertilizer and 14 Hours Photoperiod on Plant height, Number of leaves, Number of branches, Stem girth and Leaf Area***

There was a significant difference in plant height for all the treatments. Plant height varied from 149.47cm to 62.40cm. Maximum height was achieved by treatment $C_1B_2I_2$ (149.47cm). This was followed by treatment $C_3B_3I_2$ (148.47cm). The maximum no. of leaves was achieved when plants were treated with $C_1B_2I_1$ (59.2cm). The least no of leaves was achieved by treatment $C_1B_4I_1$ (40.13cm). The highest no of branches was achieved with treatment $C_1B_2I_1$ (19.07cm). However, the lowest no of branches was achieved when the plants were treated with $C_31_4I_1$ (13.07cm). There was no significant difference in the no. of branches. Stem girth differed significantly across the 24 treatment means. It varied from 4.38($C_3B_1I_1$) to 3.33 ($C_1B_1I_1$). The effect of the treatments was significant for leaf area. Treatment $C_3B_1I_1$ gave the widest leaf area value of 11.43cm$^2$. Treatment $C_1B_1I_2$ gave the lowest leaf area value of 5.55cm$^2$.

Table 1: Effect of Cowpea varieties, Biofertilizer, Inorganic Fertilizer and 14 hours photoperiod on Plant height, Number of leaves, Number of branches, Stem girth and Leaf Area in experiment 1 (May – July or early rainy season)

| Treatment | Plant height | No of leaves | No of branches | Stem Girth | Leaf Area |
|---|---|---|---|---|---|
| $C_1B_1I_1$ | $95.27_{e-h}$ | 47.87 | 15.13 | 3.33c-f | $7.76_{d-f}$ |
| $C_1B_2I_1$ | $136.87_{a-d}$ | 59.2 | 19.07 | $3.95_{a-f}$ | $9.32_{a-c}$ |
| $C_1B_3I_1$ | $100.33_{d-h}$ | 47.47 | 15.33 | $3.74_{c-f}$ | $8.24_{b-e}$ |
| $C_1B_4I_1$ | $72.13_{gh}$ | 40.13 | 13.07 | $3.88_{a-f}$ | $7.22_{ef}$ |
| $C_1B_1I_2$ | $62.40_{h}$ | 42.47 | 13.8 | $3.54_{ef}$ | $5.55_{f}$ |
| $C_1B_2I_2$ | $149.47_{a}$ | 53.47 | 17.2 | $4.16_{a-d}$ | $10.71_{ab}$ |
| $C_1B_3I_2$ | $105.53_{c-g}$ | 46.13 | 14.73 | $3.95_{a-f}$ | $8.41_{b-e}$ |
| $C_1B_4I_2$ | $94.93_{e-h}$ | 41.67 | 13.67 | $3.95_{a-f}$ | $7.33_{ef}$ |
| $C_2B_1I_1$ | $90.33_{f-h}$ | 52.4 | 16.13 | $4.14_{a-d}$ | $8.90_{b-e}$ |
| $C_2B_2I_1$ | $138.00_{a-d}$ | 53.33 | 17.13 | $3.98_{a-e}$ | $10.18_{a-d}$ |
| $C_2B_3I_1$ | $115.33_{a-f}$ | 48.07 | 15.33 | $4.18_{abc}$ | $9.32_{a-e}$ |
| $C_2B_4I_1$ | $100.67_{e-h}$ | 41.8 | 13.27 | $3.66_{d-f}$ | $7.90_{c-f}$ |
| $C_2B_1I_2$ | $90.33_{fgh}$ | 48.6 | 14.8 | $3.66_{d-f}$ | $7.32_{ef}$ |
| $C_2B_2I_2$ | $98.80_{d-h}$ | 52.6 | 16.8 | $3.94_{a-f}$ | $7.78_{d-f}$ |
| $C_2B_3I_2$ | $96.93_{d-h}$ | 51.2 | 16.4 | $4.09_{a-d}$ | $9.21_{a-e}$ |
| $C_2B_4I_2$ | $112.47_{a-g}$ | 47.07 | 17.13 | $3.96_{a-f}$ | $8.83_{b-e}$ |
| $C_3B_1I_1$ | $145.40_{abc}$ | 58.27 | 18.73 | $4.38_{ab}$ | $11.43_{a}$ |
| $C_3B_2I_1$ | $122.87_{a-f}$ | 54.6 | 17.27 | $3.88_{a-c}$ | $10.39_{abc}$ |
| $C_3B_3I_1$ | $132.80_{a-e}$ | 53.2 | 17 | $4.37_{g}$ | $9.93_{a-d}$ |
| $C_3B_4I_1$ | $109.60_{b-g}$ | 48.2 | 15.4 | $3.47_{f}$ | $8.73_{b-e}$ |
| $C_3B_lI_2$ | $97.40_{d-h}$ | 47.2 | 15.07 | $3.93_{a-f}$ | $8.82_{b-e}$ |
| $C_3B_2I_2$ | $107.27_{b-f}$ | 47.07 | 14.33 | $4.31_{ab}$ | $8.63_{b-e}$ |
| $C_3B_3I_2$ | $148.47_{ab}$ | 56.2 | 18.07 | $3.88_{a-f}$ | $10.10_{a-d}$ |
| $C_3B_4I_2$ | $115.07_{a-f}$ | 47.4 | 15.13 | $4.01_{a-e}$ | $10.11_{a-d}$ |
| Control | $42.21_{ab}$ | 21.05 | 8.16 | $0.31_{ab}$ | $2.11_{a}$ |
| LSD | 41.455 | | | 0.504 | 2.511 |

Means followed by different alphabets are different at 5% level of significance

C = Cowpea, B = Biofettilizer   I = Inorganic fertilizer

***Effect of Cowpea Varieties, Biofertilizer and Inorganic Fertilizer and 10 hours Photoperiod on Plant Height, No. of Leaves, No. of Branches and Stem Girth***

Effect of the treatments was significant for plant height. Plant height varied from 17.67cm to 29.56cm at 60DAS. Treatment $C_2B_2I_1$ gave the tallest plants (29.56cm). This was followed by treatment $C_1B_3I_1$ (26.56). Plant height was however, significantly reduced by treatment $C_2B_1I_2$ (17.67).

Maximum number of Leaves was obtained from treatment $C_1B_3I_1$ (23.23). This was followed by treatment $C_2B_2I_1$ (22.67). Treatment $C_2B_1I_2$ (15.67) gave the smallest number of leaves.

Maximum number of branches was obtained by treatment $C_2B_2I_1$ (6.90). This was followed by treatment $C_1B_3I_1$ (6.89). Treatment $C_2B_1I_2$ (4.56) gave the lowest no of branches.

Stem girth was significantly affected by the treatments. Increase in stem girth ranged from 2.99 to 3.39. Treatment $C_2B_2I_2$ gave the widest stem girth of 3.39. This was followed by treatment $C_1B_3I_1$ (3.32).

Effect of the treatments was significant on leaf area. Maximum leaf area was obtained by treatment $C_2B_2I_1$ (8.54). This was followed by treatment $C_3B_4I_1$ (8.01). Treatment $C_1B_2I_2$ gave the lowest in leaf area (3.88)

Table 2: Effect of Cowpea varieties, Biofertilizer, Inorganic fertilizer and 10 hours photoperiod on Plant height, No of Leaves, No. of Branches, Stem girth and Leaf area in experiment 2 (Sept – Nov. or late rainy season)

| Treatment | Plant height | No of leaves | No of branches | Stem girth | Leaf area |
|---|---|---|---|---|---|
| $C_1B_1I_1$ | $24.00a_{-d}$ | 20.33 | 6.11 | $3.20_{b-e}$ | $6.13_{def}$ |
| $C_1B_2I_1$ | $21.56_{bed}$ | 17.00 | 5.12 | $3.20_{b-e}$ | $6.78_{bcd}$ |
| $C_1B_3I_1$ | 26.56ab | 23.23 | 6.89 | $3.32_{ab}$ | $7.32_{a-d}$ |
| $C_1B_4I_1$ | $22.00_{b-d}$ | 18.11 | 5.40 | $3.25_{abc}$ | $7.11_{bcd}$ |
| $C_1B_1I_2$ | $21.11b_{cd}$ | 18.67 | 5.56 | $3.16_{cde}$ | $4.68_{gh}$ |
| $C_1B_2I_2$ | $20.44b_{cd}$ | 17.33 | 5.11 | $2.99_{f}$ | $3.88_{h}$ |
| $C_1B_3I_2$ | $23.56_{a-d}$ | 19.67 | 5.89 | $3.25_{abc}$ | $3.94_{h}$ |
| $C_1B_4I_2$ | $20.33_{bcd}$ | 15.78 | 4.78 | $3.28_{abc}$ | $4.04_{h}$ |
| $C_2B_1I_1$ | $21.22_{bcd}$ | 18.44 | 5.56 | $3.26_{abc}$ | $7.50_{abc}$ |
| $C_2B_2I_1$ | $29.56_{a}$ | 22.67 | 6.90 | 3.28a-c | 8.54a |
| $C_2B_3I_1$ | $18.33_{cd}$ | 19.22 | 5.77 | 3.09ef | $7.33_{a-d}$ |
| $C_2B_4I_1$ | $22.22_{bcd}$ | 19.03 | 5.67 | $3.20_{b-e}$ | $6.58_{cde}$ |
| $C_2B_1I_2$ | $17.67_{d}$ | 15.67 | 4.56 | $3.10_{def}$ | $4.20_{gh}$ |
| $C_2B_2I_2$ | $24.67_{abc}$ | 20.01 | 6.12 | $3.39_{a}$ | $5.37_{efg}$ |
| $C_2B_3I_2$ | $21.11_{bcd}$ | 19.33 | 5.80 | $3.20_{b-e}$ | $4.34_{gh}$ |
| $C_2B_4I_2$ | $21.78_{bcd}$ | 16.33 | 4.78 | $3.17_{b-e}$ | $4.28_{gh}$ |
| $C_3B_1I_1$ | $25.56_{ab}$ | 19.33 | 5.81 | $3.20_{b-e}$ | $7.18_{bcd}$ |
| $C_3B_2I_1$ | $22.78_{a-d}$ | 19.33 | 5.80 | $3.20_{b-e}$ | $7.19_{bcd}$ |
| $C_3B_3I_1$ | $25.00_{abc}$ | 19.33 | 5.78 | $3.24_{b-e}$ | $7.64_{abc}$ |
| $C_3B_4I_1$ | $23.67_{a-d}$ | 20.67 | 6.11 | $3.25_{abc}$ | $8.01_{ab}$ |
| $C_3B_1I_2$ | $22.56_{b-d}$ | 17.15 | 5.11 | $3.20_{b-e}$ | $4.58_{gh}$ |
| $C_3B_2I_2$ | $23.67_{a-d}$ | 21.33 | 6.44 | $3.22_{b-e}$ | $5.13_{fgh}$ |
| $C_3B_3I_2$ | $23.78_{a-d}$ | 19.67 | 5.89 | $3.24_{bcd}$ | $4.06_{h}$ |
| $C_3B_4I_2$ | $22.22_{bcd}$ | 19.33 | 5.81 | $3.26_{abc}$ | $4.61_{h}$ |
| Control | $11.21_{ab}$ | 9.43 | 4.01 | $1.08_{ab}$ | 1.46 |
| LSD | 6.801 | | | 0.149 | 1.263 |

Means followed by different alphabets are different at 5% level of significance

C = Cowpea, B = Biofettilizer I = Inorganic fertilizer

***Effect of Cowpea Varieties, Biofertilizer, Inorganic Fertilizer and 10 Hours Photoperiod on Pods per Plant (PPP) Pod fresh Weight (PFW), Pod Dry Weight (PDW) and no of seeds per pod (NSPP) in experiment 2***

Pods per plant varied from 3.67 to 7.00. Treatment $C_2B_4I_2$ gave the maximum number for PPP (7.00). This was followed by treatment $C_2B_3I_1$ (6.67). Treatment $C_1B_2I_1$ (3.67) gave the least value for PPP. Pod fresh weight ranged from $C_1B_2I_1$ (1.20) to $C_3B_3I_1$ and $C_1B_2I_1$ (1.67).

Range for Pod dry weight was from 0.01 ($C_1B_2I_1$) to 0.68 ($C_1B_1I_2$). Maximum increase for NSPP was achieved by treatment $C_2B_2I_2$ (7.67). This was followed by $C_1B_1I_1$, (7.33). Least NSPP was achieved by treatment $C_1B_4I_1$ (4.33)

Table 3: Effect of Cowpea varieties, Biofertilizer, Inorganic Fertilizer and 10 hours photoperiod on Pods per plant (PPP) Pod fresh weight (PFW), Pod dry weight (PDW) and no of seeds per pod (NSPP) in experiment 2 (Sept – Nov or late rainy season)

| Treatment | PPP | PFW | PDW | NSPP |
|---|---|---|---|---|
| $C_1B_1I_1$ | 5.00 | 1.33 | 0.03 | 7.33 |
| $C_1B_2I_1$ | 3.67 | 1.67 | 0.01 | 6.33 |
| $C_1B_3I_1$ | 6.00 | 1.57 | 0.21 | 5.00 |
| $C_1B_4I_1$ | 5.00 | 1.3 | 0.16 | 4.33 |
| $C_1B_1I_2$ | 4.67 | 1.14 | 0.68 | 6.33 |
| $C_1B_2I_2$ | 5.00 | 1.37 | 0.21 | 5.33 |
| $C_1B_3I_2$ | 6.00 | 1.63 | 0.27 | 5.67 |
| $C_1B_4I_2$ | 5.67 | 1.33 | 0.07 | 5.33 |
| $C_2B_1I_1$ | 5.67 | 1.27 | 0.1 | 5.33 |
| $C_2B_2I_1$ | 5.00 | 1.27 | 0.08 | 4.67 |
| $C_2B_3I_1$ | 6.67 | 1.53 | 0.24 | 5.00 |
| $C_2B_4I_1$ | 6.00 | 1.33 | 0.15 | 5.67 |
| $C_2B_2I_2$ | 6.33 | 1.43 | 0.25 | 7.67 |
| $C_2B_3I_2$ | 5.67 | 1.47 | 0.21 | 5.00 |
| $C_2B_4I_2$ | 7.00 | 1.60 | 0.22 | 5.67 |
| $C_3B_1I_1$ | 4.33 | 0.97 | 0.05 | 5.00 |
| $C_3B_2I_1$ | 5.67 | 1.47 | 0.19 | 5.67 |
| $C_3B_3I_1$ | 5.33 | 1.67 | 0.03 | 5.67 |
| $C_3B_4I_1$ | 5.00 | 1.24 | 0.08 | 5.33 |
| $C_3B_1I_2$ | 4.00 | 0.87 | 0.02 | 5,00 |
| $C_3B_2I_2$ | 5.00 | 1.30 | 0.04 | 5.33 |
| $C_3B_3I_2$ | 4.33 | 0.96 | 0.04 | 5.00 |
| $C_3B_3I_2$ | 4.00 | 1.20 | 0.06 | 5.33 |
| Control | 1.32 | 0.05 | 0.01 | 1.31 |
| LSD | | | | |

Means followed by different alphabets are different at 5% level of significance
C = Cowpea B = Biofettilizer I = Inorganic fertilizer

***Physical and Chemical properties of experimental soil***

The Physical properties of the experimental soil suggests that the texture of the soils varies, with most being classified as Loamy sand (LS) and one as sandy loam. The pH values ranged from 5.92-6.98, indicating slightly acidic to neutral soil conditions. The EC (Electrical Conductivity) values are relatively low, ranging from 0.01-0.016, indicating low soil salinity. The total nitrogen content is relatively low (0.105%), indicating a potential nitrogen deficiency in the soil. The available phosphorus content is relatively high (26.39%), indicating that the soil has sufficient phosphorus availability for plant growth.

The exchangeable cation values (Calcium (Ca): 3.00 cmol/kg, Magnesium (Mg): 0.15 cmol/kg Potassium (K): 0.15 cmol/kg, Sodium (Na): 1.20 cmol/kg), represent the amounts of each cation that are exchangeably bound to the soil's cation exchange sites. They indicate the availability of these cations for plant uptake.

The values for Hydrogen and Aluminum (H+Al = 0.60 cmol/kg), represent the amount of hydrogen and aluminum ions that are bound to the soil's cation exchange sites. These ions can contribute to soil acidity and affect nutrient availability. A moderate level (0.60 cmol/kg) was present in the experimental soil. The Cation Exchange Capacity (CEC =5.20 cmol/kg), measures the soil's ability to hold and exchange cations (positively charged ions). It is an indicator of soil fertility and nutrient-holding capacity. A relatively low CEC value (5.20 cmol/kg) suggests that the soil may have limited capacity to retain and exchange nutrients. The baseline values of the results of this experiment, provide a reference point for evaluating the effects of adding biofertilizer and single superphosphate on soil nutrient availability.

Table 4: Physical and chemical properties of experimental soil

| | $B_1I_1$ | $B_1I_2$ | $B_2I_1$ | $B_2I_2$ | $B_3I_1$ | $B_3I_2$ | $B_4I_1$ | $B_4I_2$ | Control |
|---|---|---|---|---|---|---|---|---|---|
| %Clay | 8 | 10 | 10 | 8 | 10 | 10 | 10 | 12 | 8 |
| %Silt | 10 | 10 | 8 | 8 | 8 | 10 | 6 | 8 | 8 |
| %Sand | 82 | 80 | 82 | 84 | 82 | 80 | 84 | 80 | 84 |
| Text class | LS | LS | LS | LS | LS | LS | LS | SL | LS |
| Ph | 6.88 | 6.73 | 6.98 | 6.01 | 6.93 | 6.05 | 6.07 | 5.92 | 6.47 |
| EC | 0.016 | 0.015 | 0.01 | 0.012 | 0.011 | 0.015 | 0.014 | 0.013 | 0.01 |
| Org. C(%) | 1.476 | 1.237 | 1.436 | 1.237 | 1.337 | 1.217 | 1.097 | 1.257 | 0.279 |
| Total N (%) | 0.245 | 0.14 | 0.175 | 0.105 | 0.175 | 0.175 | 0.14 | 0.175 | 0.105 |
| Avail. P (%) | 29.12 | 28.10 | 33.2 | 37.53 | 39.79 | 37.15 | 28.28 | 31.3 | 26.39 |
| Ca (cmol/kg) | 3.7 | 5.10 | 2.80 | 2.90 | 4.10 | 3.10 | 2.70 | 4.10 | 3.00 |
| Mg(cmol/kg) | 0.3 | 0.58 | 0.48 | 0.47 | 0.12 | 0.3 | 0.37 | 0.27 | 0.15 |
| K(cmol/kg) | 0.3 | 0.58 | 0.48 | 0.47 | 0.12 | 0.3 | 0.37 | 0.27 | 0.15 |
| Na(cmol/kg) | 2.7 | 3.56 | 2.79 | 3.62 | 2.62 | 3.73 | 2.79 | 3.73 | 1.20 |
| H+Al(cmol/kg) | 0.60 | 0.60 | 0.60 | 0.80 | 0.80 | 0.40 | 0.60 | 1.00 | 0.60 |
| CEC(cmol/kg) | 7.60 | 10.20 | 7.40 | 8.30 | 8.10 | 7.90 | 6.80 | 9.60 | 5.20 |

$B_1$ = Biofertilizer 1, $B_2$= Biofertilizer 2, $B_3$=Biofertilizer 3, $B_4$ = Biofertilizer 4, $I_1$= Inorganic fertilizer 1, $I_2$ = inorganic fertilizer

## DISCUSSION

The impact of photoperiodism on the growth and yield of cowpea (*Vigna unguiculata*) is a critical factor in tropical agriculture. Cowpea is a photoperiod-sensitive crop that responds to photoperiod, which affects its growth and yield (Adebisi *et al*., 2020). This study investigated the impact of photoperiodism on the growth and yield of cowpea grown with biofertilizer and inorganic fertilizer in early and late rainy seasons.

There was much variation in plant height between experiments 1 and 2. Photoperiodism significantly affected cowpea growth and yield. The longest photoperiod (14 hours) promoted vegetative growth only as seen in experiment 1, while the shortest photoperiod (10 hours) induced flowering and pod formation as recorded in experiment 2 (Kumar *et al*., 2019). Maximum height recorded in experiment 1 was 149.57cm ($C_1B_2I_2$). The least height was 62.40m ($C_1B_1I_2$). In experiment 2, the maximum height recorded was 29.56m ($C_2B_2I_1$) while the lowest was 17.67 ($C_2B_1I_2$). This is attributed to photoperiodism which is the regulation of physiology or development in response to day length. In photoperiodism, flowering and other developmental processes are regulated in response to the photoperiod or day length. It allows some plants to flower and switch to reproductive mode only at certain times of the year. Floral bud initiation and development is sensitive to photo period in many cowpea accessions. These findings are consistent with previous studies that reported that cowpea responds to photoperiod by altering its growth and development (Okeleye *et al*., 2020).

The application of biofertilizer and inorganic fertilizer also significantly affected cowpea growth and yield. The combination of biofertilizer and inorganic fertilizer enhanced cowpea growth and yield, particularly under the shortest photoperiod (Adebisi *et al*., 2020). This suggests that the use of biofertilizer and inorganic fertilizer can optimize cowpea production in tropical regions.

The interaction between photoperiod and fertilizer application was also significant. The longest photoperiod (14 hours) reduced the effectiveness of fertilizer application, while the shortest photoperiod (10 hours) enhanced the effectiveness of fertilizer application (Kumar *et al*., 2019). This suggests that photoperiod affects the uptake and utilization of nutrients by cowpea.

The results of the physical and chemical properties of the experimental soil indicate that the experimental soils exhibited varying physical and chemical properties, which were influenced by the different biofertilizers and inorganic fertilizers used (Table 4). The pH values ranged from 5.92 to 6.98, indicating a slightly acidic to neutral soil conditions (Hue and Licudine, 1999). The electrical conductivity (EC) values were relatively low, ranging from 0.01 to 0.016, indicating low soil salinity (Ayers and Westcot, 1994).

The organic carbon content varied across the treatments, with values ranging from 0.279% to 1.476%. This variation is consistent with the findings of other studies carried out by Wani *et al*. (2013) and Singh *et al*. (2020), who reported significant effects of biofertilizers on soil organic carbon content. The total nitrogen content ranged from 0.105% to 0.245%, which is within the typical range for agricultural soils (Havlin *et al*., 2014).

The available phosphorus content varied significantly across the treatments, with values ranging from 26.39% to 39.79%. This variation is consistent with the findings of Kumar *et al*. (2022), who reported significant effects of biofertilizers and inorganic fertilizers on soil available phosphorus content.

The exchangeable cation content, including calcium, magnesium, potassium, and sodium, also varied across the treatments. These variations are consistent with the findings of Yadav *et al*. (2017) and Meena *et al*. (2016), who reported significant effects of biofertilizers and inorganic fertilizers on soil exchangeable cation content.

The cation exchange capacity (CEC) values ranged from 5.20 to 10.20 cmol/kg, indicating moderate to high CEC. This variation is consistent with the findings of Brady and Weil (2008), who reported significant effects of biofertilizers and inorganic fertilizers on soil CEC.

The results of this study indicate that the experimental soils exhibited varying physical and chemical properties, which were influenced by the different biofertilizers and inorganic fertilizers used. These findings are consistent with the results of Kumar *et al*. (2022) who reported significant effects of biofertilizers and inorganic fertilizers on soil properties.

## CONCLUSION

The impact of photoperiodism on the growth and yield of cowpea is significant, and the application of biofertilizer and inorganic fertilizer can optimize cowpea production in tropical regions. The interaction between photoperiod and fertilizer application is also critical, and further research is needed to understand the mechanisms underlying this interaction.

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