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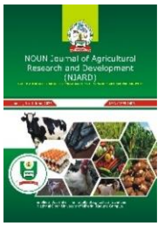

Original Article

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Effect of Variety and Planting Date on Cowpea Growth in Maize-Cowpea Intercrop in Southern Guinea Savannah, Kwara State

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ABSTRACT

On-Farm Adaptive Methodology was used in conducting the present study in Ioffa and Offa. both situated within the wet Savannah of Nigeria. The main objective of the study was to launch cowpea to the status of a major crop and farming system in the ecological. The cowpea varieties (ITZ-82-90-SAMPEA17, Ex-Borno and Ife Brown) were tested against three sowing dates. The data collected were subjected to ANOVA, and means were separated using LSD at the P≥0.05 level of significance. Variety × Sowing Date significantly (P ≤ 0.05) reduces days to 50% flower initiation to as low flowering was recorded from the interaction of Ife Brown with the individual sowing dates and the interaction of Ex-Borno versus the 3 sowing dates. The interaction of (the three) sowing dates and both Ife Brown and Ex-Borno resulted in a higher nodule count in the range of 52-61. Other morphological traits like plant height and relative growth rate were likewise significantly (P ≤ 0.05) influenced by variety × sowing date. The individual interaction of Ex-Borno and Ife Brown with sowing on 13/09/2023recorded the highest cowpea grain yield from the two locations of the experiment. An average cowpea grain yield of 1109 and 1106.5 kg/ha was recorded from Iloffa and Offa, respectively. Based on the findings, both Ife Brown and Ex-Borno were recommended for late sowing on the 13th *of September in the wet Savannah.*

Keywords: *Cowpea, inter-cropping, variety/varieties, and* sowing date

INTRODUCTION

Cowpea is a significant field crop and a staple food in Nigeria. It earned the acceptable status due to its valuable nutritional qualities. (Shevkani, 2025). Apart from the formidable nutritional attributes, cowpea is also a valuable fodder crop and green manure (Singh *et al.*, 2023; Fabunmi and Balogun, 2015). Despite the awareness of its relevance to man, animals, and the environment, cowpea production and productivity are yet to attain the desired commendable and dependable level of cultivated hectare. The productivity on farmers' land still ranks, in most cases, within a low range of 350 to 500 kg/ha (Abdullahi & Tsowa, 2014). Reasons for the poor field performance of cowpea in Nigeria, according to Bondok et al. (2024), include an inherent low soil nutrient status, which is a consequence of poor management and a total neglect of conservation and sustainability. Lal (2009) reported that good soil management via sustainable crop husbandry is a requirement. This is especially important in efforts to improve soil productivity. Ayalew and Yoseph (2022) supported the claim that cowpea husbandry is the most appropriate choice of crop in the event of vicious climate change.

Petu-Ibikunle et al. (2012) established that there is a strong correlation between global/national economic recession and climate change. The two phenomena interact to contribute immensely to rendering agricultural production more capital intensive with low productivity (Modu et al. 2010; Tchonkouang et al. 2024; Saleem et al. 2024). Consequently, the effect of climate change is biting harder with a clearer expression. Farmers now see a shift in the farm activity calendar that disrupts action plans. This is because weather can no more be accurately predicted for the purpose of scheduling cropping activities (Ajetomobi & Abiodun 2010). A more earnest implication of climate change is the detrimental effect on some conventional agronomic practices like sowing date and appropriate seed technology (Agwu 2004), such as tolerances to drought, multiple resistance to biotic stress, and sensitivity to photoperiodism, as reported by Kiprotich et al. (2015), Bolarinwa et al. (2022), and Bolarinwa et al. (2023).

It is thus relevant at this juncture to unveil the fact that the bulk of the cowpea presently consumed in other parts of Nigeria is cultivated in the northern Guinea Savannah (Bass, 2024; Kebede, 2020) and then transported to other regions.

This explains why transportation costs have significantly impacted the availability and skyrocketing market price of cowpea (Ajiboye & Afolayan 2009). Another major issue worthy of addressing is the fact that the mixed farming system of maize and cowpea intercrop is a northern Guinea Savannah concept. While relay cropping is typical of southern Nigeria (Foli 2012). Efforts to boost cowpea production in the wet savannah zone of Nigeria may thus be fruitless, except for adoption taking into consideration. This is in view of the fact that the mixed farming system may, for the time being, be alien to the wet savannah farmer.

Efforts are therefore required to boost cowpea productivity by applying the three pillars of food security (which are enhanced productivity, availability and accessibility). To achieve this, a sustainable long-term productivity intervention is required. This can be achieved by making efforts to expand and extend cowpea production in the northern Guinea Savannah, a zone that presently dominates catchment cowpea production in Nigeria.

The objective of the study is thus structured to achieve the following:

i) Increase cowpea cultivation and productivity in the wet guinea savanna zone of Nigeria.

ii) Incorporate (via on-farm adaptive strategy) cowpea: maize mixed-inter cropping farming system into the wet guinea savanna

iii) Determine the best sowing date for cowpea established in maize inter-crop in the wet Savannah zone of Nigeria.

iv) Determine the best-adapted cowpea variety under the cowpea-maize inter cropping farming system in the wet Guinea savanna.

Materials and Methods

a) Description of the Experimental Location

The bi-location experiment was conducted in Kwara State, situated in the middle belt of Nigeria. Location 1: Iloffa, in Oke Ero, Kwara State, Nigeria, with a coordinate of 8º06´25.2″N 5º08´16.8″E; while location 2: Offa, the second location, with a coordinate of 8°9′N 4°43′E. The climate pattern has two seasons of about 6-7 months of rainfall with an onset in March-April, a break in August, and the second season lasts till mid-November. The temperature ranges from 22°C to 33°C annually. The photo-period on a cloudy day could be up to 12-15 hours of sunshine (NiMet, 2023).

b) Experimental Treatments and Design

On-farm adaptive research methodology was used to achieve the major objective of this study. This involved a purposeful sampling of nine farmers from each experimental location. At each location, the farmers were grouped into 3 to achieve 3 replications, which each farmer's field eventually represented.

The experiment was designed in a 3 cowpea varieties x 3 sowing dates x 2 spatial arrangements factorial combination of:

Cowpea Varieties (i) ITZ-82-2-SAMPEA17 (ii) Ex-Borno (iii) Ife Brown and maize variety (TZESR-W: An early-maturing white variety resistant to MSV and Downy Mildew)

Sowing Dates (i) 30/08/2023 (ii) 06/09/2023 (iii) 13/09/2023

3). Crop geometry arrangement/Spatial arrangements of maize: cowpea inter-crop (i) 1:2 and (ii) 2:4

c.) Agronomic Practices

The experimental fields were cleared of old vegetation. To achieve a well-pulverized seedbed, ploughing and harrowing were done with a tractor. A bio-insecticide (nicotine extract from tobacco leaf) was applied at pre-flower initiation, full-flower initiation and full-pod formation developmental phases.

Seed inoculation: Inoculation was achieved via Saskatchewan (2023). A powder-formulated bio-fertiliser was applied as seed inoculation, and gum Arabic was used as an adhesive to mildly moisten the seed. Then 250g of inoculant was added to every 10kg of seed. Agitation was manually done until all the seeds were visibly seen to have been coated entirely by bio-fertilizer.

d.) Measurements/Data Collection

i. Days to 50% flowering

Days to 50% flowering: The experimental plots were observed on a daily basis from the day the first plant was observed to have initiated flower buds until about 50% of the plants on each plot had flowered.

ii. Plant height (cm)

The plant height was measured with a ruler. The ruler was placed on the ground next to the stem and measured to the height of the tallest part of the stem. (Ignoring the leaves).

iii. Leaf Area (cm²)

The graph paper method was used to trace the leaf. This was according to the methodology of Pandey & Singh, H. (2011) in Addai & Alimiyawo (2015).

iv. Nodule count

At four weeks after sowing, 15 cowpea plants per treatment were carefully uprooted from each plot. The roots were gently washed with water to remove soil. With the aid of a blunt knife, the nodules were gently detached from the roots. Once the nodules were separated, the counting was done using a hand lens to aid the vision.

v. Relative growth rate (RGR) g $g^{-1}day^{-1}$

The Initial Weight (M1) of the fresh plant was taken from the 15 sampled cowpea plants. This was the weight of the plant at the beginning of the observation period of 4 weeks (t1); after sowing, it was again taken at 6 weeks after sowing (M2). This is the weight of the plant at the end of the observation period, measured using the same unit as M1 but at 6 weeks (t2) after sowing. The time interval (t2 - t1) is thus determined. According to Lamont (2023):

$$RGR = \frac{InW2 - InW1}{t2 - t1}$$

InW_2 = atural log first weight, InW_1 = Natural log final weight and $t_2 - t_1$ = interval

vi. Net Assimilation Rate (g m^{-2} day^{-1})

A crop stand of cowpea was destructively harvested. In measuring the initial weight of the plant (W1) when the plants were at 4 weeks (t_1) of planting. The final weight W2 was taken at 6 weeks (t2) after sowing. The interval was determined as t_1-t_2. The Initial Weight (M1) of the fresh plant was taken from the 15 sampled cowpea plants. This was the weight of the plant at the beginning of the observation period of 4 weeks (t1); after sowing, it was again taken at 6 weeks after sowing (M2). This is the weight of the plant at the end of the observation period, measured using the same unit as M1 but at 6 weeks (t2) after sowing. The leaf area at two intervals of 4 and 6 weeks was taken at L_{A1} and L_{A2}. The leaf dry matter yield (cm) was calculated as W1 for the initial weight at 4 weeks after sowing and W2 at 6 weeks after sowing. The computation of NAR was done using the Vernon & Allison (1963) formula in Goudriaa, J. and Monteith, J.L. (1990).

$$NAR = \frac{W2 - W1}{t_2 - t_1} \times \frac{InL_{A2} - InL_{A1}}{L_{A2} - L_A}$$

* LA1 and LA2 are natural logs of cowpea leaf area taken at different times t_1 and t_2, and W1 = first weight and W2 = second weight at 14 days after the first reading

vii. Grain Yield (kg/ha)

The grain yield was measured by harvesting pods from an outlined plot. The pods were manually threshed, and drying was achieved using an electrical oven to achieve a consistent moisture level of 14%, after which the dried seeds were weighed on a digital scale. This weight was further adjusted for the plot size and plant density to calculate yield per hectare (t/ha). using the formula (gross yield from plot / plot area in cm^2) × 10,000 × (adjusted plot area / total plot area) / 1000

e). Statistical Analysis of Data

The data collected were subjected to statistical analysis using the Statistix 8.0 package. Means were separated for level of significance at 95% ($P \leq 0.05$) level of confidence interval. The results were presented in graphical bar charts.

Result and Discussion

i.) Days to 50% Flower Initiation

The treatments (variety × sowing dates) were significantly ($P \leq 0.05$) different from one another at location 1. (Figure 1a). The most significant delay of 58.2 days to attain 50% flower initiation was recorded from Ife Brown×13/09/2023, while IT90K-82-2 SAMPEA17×30/08/2023 attained 50% flower initiation in 31.5 days. The result from location 2 (Figure 1b) is inconsistent with location 1. The treatments' interactions were significantly different ($P \leq 0.05$). The interaction of Ife Brown when sown either on 06/09/2023 or recorded the most significant ($P \leq 0.05$) delay of 59 and 57 days to attain 50% flower initiation. The interaction of variety IT90K-82-2 SAMPEA17 with the three sowing dates (30/08/2023, 06/09/2023, and 13/09/2023) recorded similar reductions of 36.5, 38, and 39.5 days to 50% flowering.

The results obtained from the variety × sowing dates and the effect on days taken for 50% of the crop to initiate flowering, as observed in the present study, agree with Nwofia et al. (2018); Matoso et al. (2018); Popoola et al. (2024); Ewansiha et al. (2014); and Alidu (2019). The scholars opined that cowpea, being light sensitive, was influenced by photosynthetically active radiation (PAR), a phenomenon that varies with the sowing date. The variation in sowing date can also manifest as differential temperature, a paramount factor that dictates physiological processes such as flower initiation.

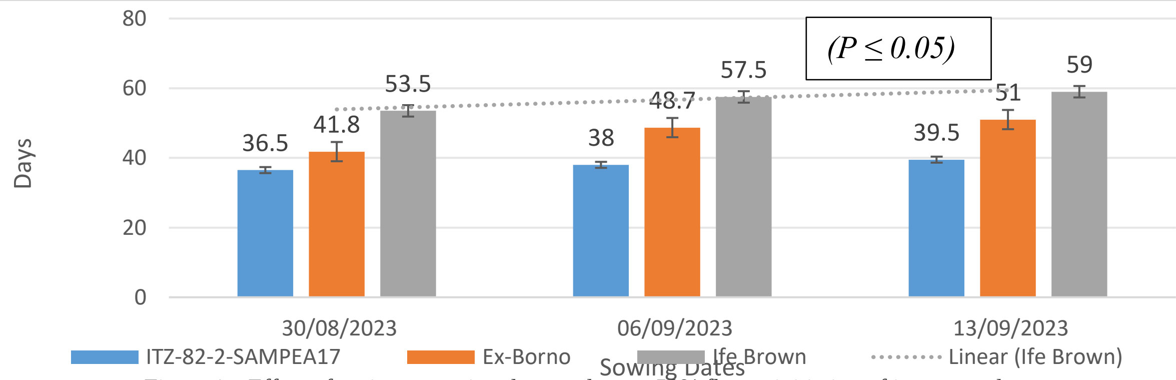

Figure 1a: Effect of variety x sowing date on days to 50% flower initiation of intercroped cowpea at Iloffa

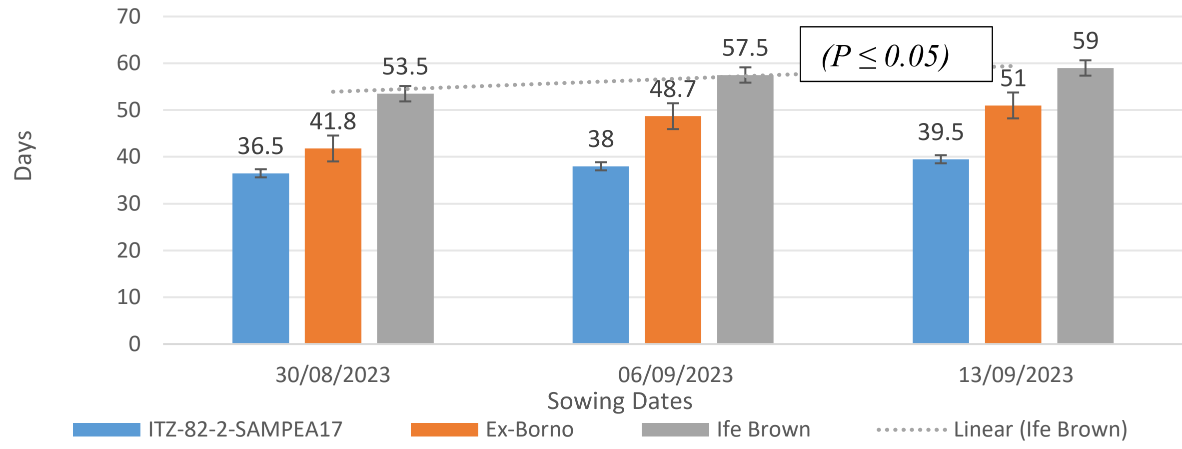

Figure 1b: Effect of variety x sowing date on days to 50% flowering of intercroped cowpea at Offa

Further explanations by Friend et al. (2011); Zhang et al. (2022); Heide et al. (2020); and Zhen et al. (2021) reveal that heat stress can impact flowering via interference with the expression of related genes. While a vital consequence of the climatic variability created by the moisture regime can also stimulate early flowering in plants. According to Chen et al. (2025); Yang et al. (2021); Margay et al. (2024); Guo et al. (2023); and Sønsteby & Heide (2023). The resultant early flowering is a survival adaptation trait. The fluctuations in the climatic elements stimulate/activate growth regulators such as salicylic acid, gibberellins, and abscisic acid. These growth regulators are the molecular sympathisers released by the plants to facilitate the flower initiation as a survival adaptation strategy.

ii.) Plant Height (cm)

There are 5 groups of treatment interactions (variety × sowing dates) with eans that were not significantly ($P \leq 0.05$) different. (Figure 2a). The interactions of the other two varieties (Ife brown and Ex-Borno) with the three sowing dates (30/08/2023, 06/09/2023 and 13/09/2023) produced the tallest plants that were not significantly ($P \leq 0.05$) different from one another. The tallesmt plant ranged from 31 (from Ife Brown × 06/09/2023) to 29.5 cm (for Ife Brown × 13/09/2023). The shortest plants were recorded from all the interactions of ITZ-82-2 SAMPEA17 with the individual sowing dates (30/08/2023, 06/09/2023 and 13/09/2023).

The plant height from the interactions of Ife Brown and Ex-Borno with the individual sowing dates (30/08/2023 and 06/09/2023) recorded the tallest plants that were significantly ($P \geq 0.05$) similar in the range of 35.5 cm from Ife Brown × 30/08/2023 to Ife Brown × with a plant height of 34.5 cm. The interaction of variety ITZ-82-2-SAMPEA17 with the individual sowing dates (30/08/2023, 06/09/2023 and 13/09/2023) recorded the significantly ($P \leq 0.05$) shortest plants.

The result from the present study is consistent with Legese et al. (2021) and Kammoun et al. (2021). Demie et al. (2022). inter-cropping dynamics may be the reason for the present result. The fitness of an intercropped cowpea variety for an enhanced competitive ability depends on the compatibility of the component crops.

The interaction implies that some varieties might be more adaptable to a wider range of sowing dates than others. Gommers et al. (2013) and Ince et al. (2021) explained that plants grow taller in response to warm temperatures (note that temperature regimes may vary during the growing season as the sowing date is varied) in an adaptation effort to maintain an optimum carbon balance in their tissues.

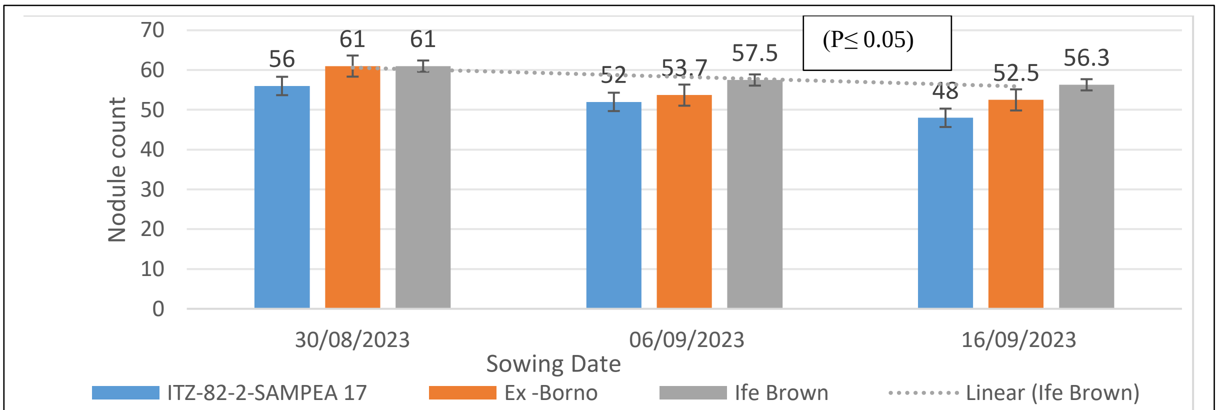

Figure 2a: Effect of variety x sowing date on nodule count of intercroped cowpea at Iloffa

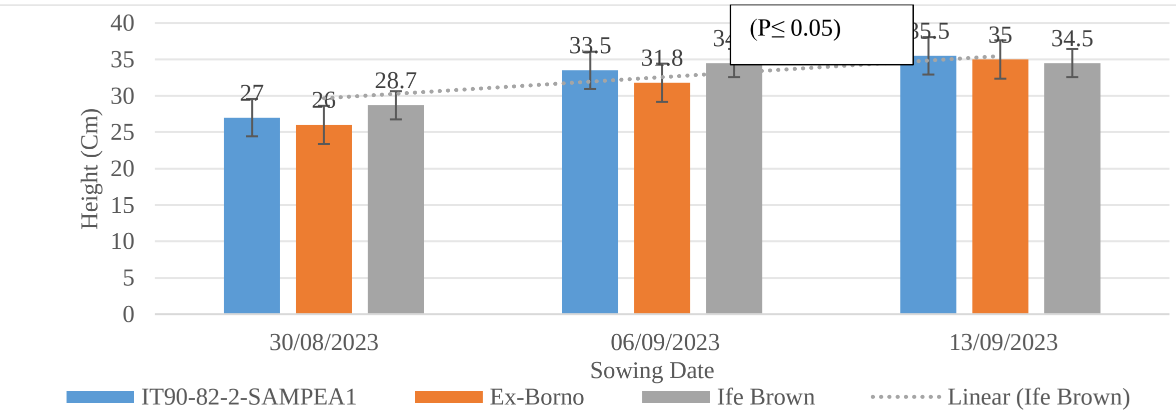

Table 2b: Effect of the Interaction of Cowpea Variety x Sowing Date on Height of Intercroped Cowpea at Offa

Different cowpea varieties store a lot of chemical energy in the form of fats and proteins that can be used to survive under low illumination conditions. When the stored resources are exhausted, the plant requires light to grow taller. The overall plant height will thus be decided by the variety x sowing date (which comprises a series of variations in photoperiod/light intensity, temperature and moisture regime). Plants under shade make attempts to optimise photosynthesis as an adaptation to the low level of illumination. Increase in height is actually a shade-avoidance syndrome, a growth response to escape shade. Light is a vital resource for plants, which compete for it, particularly in dense communities. Plants have multiple photo-sensory receptors to detect the presence of competitors and thereby adjust their growth and developmental strategies accordingly. Under poor illumination, growth hormones do not slow stem elongation. Hormones (auxins) make cells located on the dark side of the plant grow taller, which, according to Ince et al. (2022), explains why plants bend or grow towards light. In general, an increase in height is a phenomenal response to reaching out for light (phototropism); plants avoid shade by growing taller.

iii.) Leaf Area 4 Weeks (cm²)

There are 6 groups (variety × sowing date) at location 1 with means that were not significantly ($p \geq 0.05$) different (Figure 3a). The widest leaf area (122.2 cm²) was recorded from the interaction of Ex-Borno × Sowing on 30/08/2023 (Figure 3b) from location 2. A similar result for location 2. These results are consistent with Hunt (2017) and Salem (2020).

The present result can be explained by varietal variation responding to variations and modifications in the atmospheric conditions in response to the various sowing dates. Cowpea varieties possibly vary in levels of tolerance to different environmental conditions created by varying the sowing dates. The varietal differences in crop exhibited in the form of growth habits (including leaf size) can also impart variations in leaf area response to sowing dates.

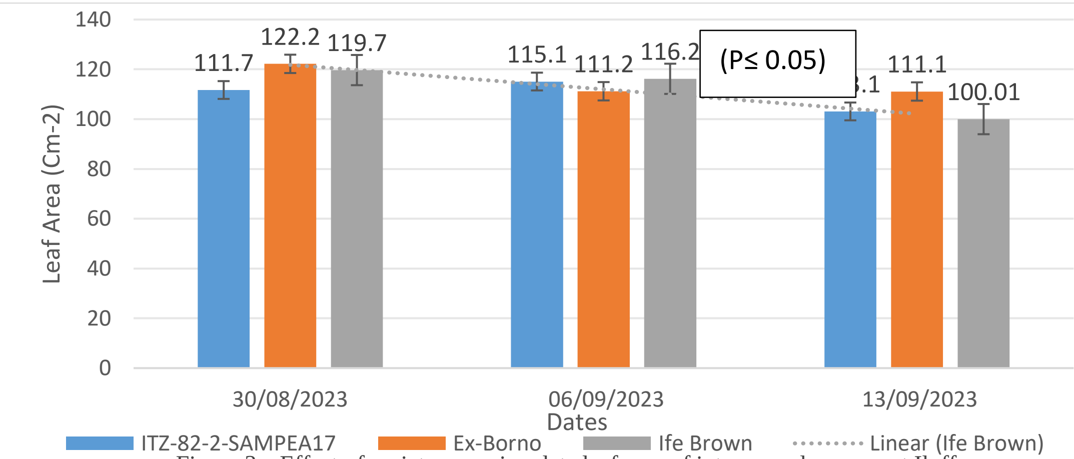

Figure 3a: Effect of variety x sowing date leaf area of intercroped cowpea at Iloffa

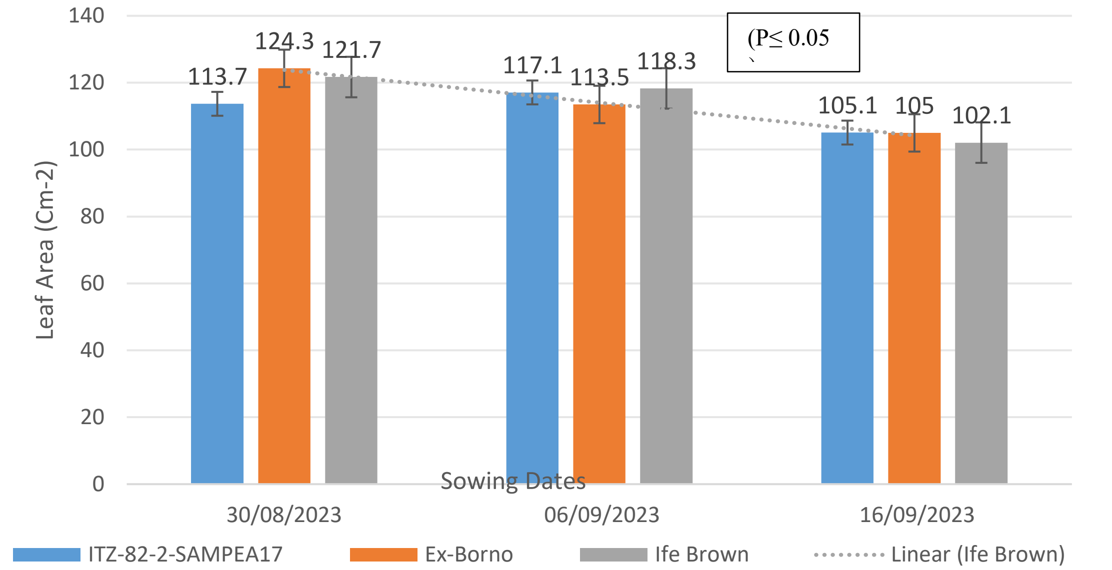

Figure 3b: Effect of variety x sowing date on leaf area of intercroped cowpea at Offa

The influence of intercropping was also capable of grossly affecting factors like light availability, temperature, nutrient uptake, and water competition. These might have further influenced cowpeas' utilisation of resources like light, H_2O, and nutrients. For a counterpart crop (maize) sown earlier than the cowpea, it may have an initial advantage or be favoured to better compete for resources. This will temporarily impact the cowpea's leaf area development of cultivars that are less tolerant or adapted to competition. The competition and resource utilisation may eventually lead to variations in leaf area, as leaf area development is closely linked to resource utilisation and photosynthetic capacity. As a trait of good adaptation to fitness competition and survival, the crops tend to maximise their surface area for an enhanced trapping/capturing of photosynthetically active radiation. The expansion of leaves under the shade can be further discussed from a molecular point of view; records document that the light environment alters in both quantity and quality under shade conditions. In response to the consequent reduction in PAR, leaf expansion will be subsequently regulated by auxins and gibberellins, with a significant role also played by cytokinins. These hormones are generally associated with leaf growth enhancement, which can also be expressed as shade avoidance, as explained by Wu et al. (2017) and Fernández-Milmanda & Ballaré (2021). Ghorbel et al. (2023); Li et al. (2023)

v.) Nodule Count

There are 8 groups (variety × sowing date) of treatments at location 1 (Figure 4a) with means that are not significantly ($P \leq 0.05$) different from one another. Ex-Borno × 30/08/2023, and Ife Brown × 30/08/2023. Produced the highest nodule count of 61 from location 1. While at location 2 (Figure 4b), there were 8 groups (Variety × Sowing Date) with means that were not significantly different. Ife Brown × Sowing on 30/08/2023 (with 57.5 nodules) and Ex Borno × Sowing on 30/08/2023 (with 57.3 nodules) recorded the highest nodule counts, which were, however, significantly ($P \leq 0.05$) similar.

In the present trial, cowpea variety × sowing date remarkably influences nodulation; this is probably because certain cowpea varieties are more sensitive to environmental factors, as modified by the timing of planting and the associated climatic element variations. In response to the variations in prevailing weather conditions and the contributions of the intercropping phenomenon, it is possible for cowpeas to exhibit variations in their nodulation. An early sowing may coincide with wet periods, which can potentially impact nodule development. While a delayed sowing can decrease branch numbers, which may consequently impair nodule count. These observations are in agreement with Munjonji et al. (2018); Ndagana et al. (2023); Aliyu et al. (2023); Egbe et al. (2013); Tesfaye & Nebiyu (2021). Leveraging further on the work of Yusuf et al. (2018), we can discuss further that cowpea varieties are sensitive to environmental factors, which was supported by Ayalew et al. (2024), who found that based on their tolerance, susceptibility and general adaptation to the created intercrop and sowing date circumstances and conditions, certain varieties may nodulate better under specific sowing dates.

Nodulation, according to Bationo et al. (2002), can be affected by inherent soil fertility status. As a result of this, the more the delay in the sowing date of cowpea, the more likely the earlier sown component member of the intercrop has the tendency of exhausting or depleting the soil nutrients prior to cowpea establishment.

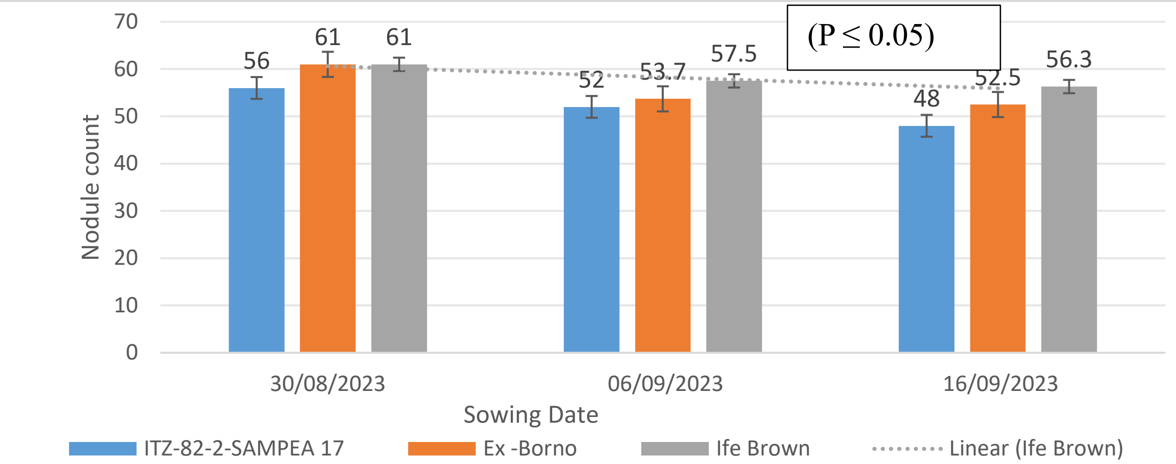

Figure 4a: Effect of variety x sowing date on nodule count of intercroped cowpea at Iloffa

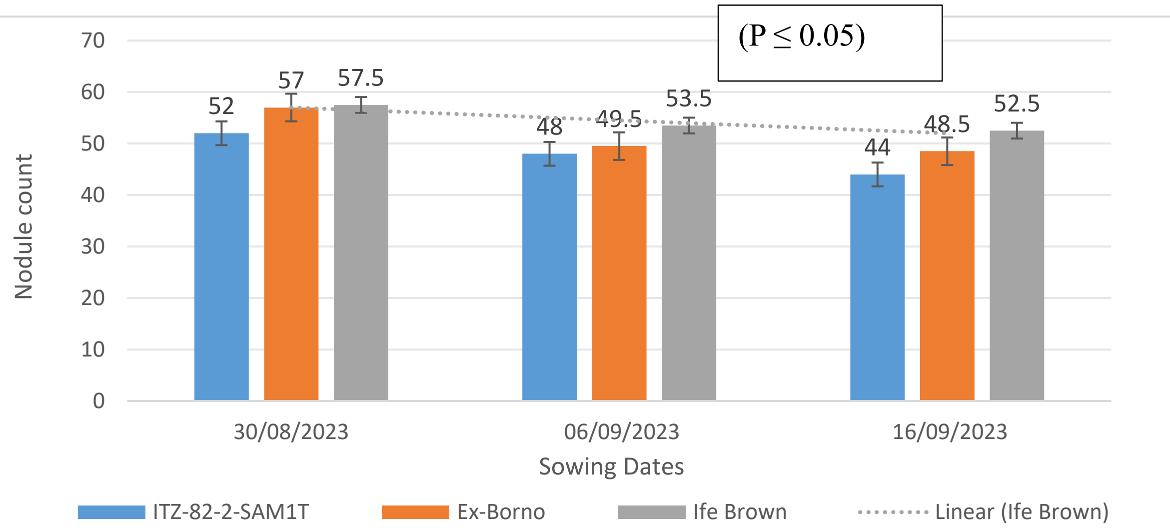

Figure 4b :Effect of variety x sowing date on nodulation of intercroped cowpea at Offa

While a delayed sowing can decrease branch numbers, which may consequently impair nodule count. These observations are in agreement with Munjonji et al. (2018); Ndagana et al. (2023); Aliyu et al. (2023); Egbe et al. (2013); Tesfaye & Nebiyu (2021). Leveraging further on the work of Yusuf et al. (2018), we can discuss further that cowpea varieties are sensitive to environmental factors, which was supported by Ayalew et al. (2024), who found that based on their tolerance, susceptibility and general adaptation to the created intercrop and sowing date circumstances and conditions, certain varieties may nodulate better under specific sowing dates.

Nodulation, according to Bationo et al. (2002), can be affected by inherent soil fertility status. As a result of this, the more the delay in the sowing date of cowpea, the more likely the earlier sown component member of the intercrop has the tendency. According to Marsh et al. (2006), extreme cases of temperature values can also inhibit nodulation, while (low or high) temperature can also inversely impact the legume-Bradyrhizobium symbiosis. Soil moisture regime (drought/moisture stress or flood/water logging) as a component of seasonality created by sowing date, according to Lumactud et al. (2023), is another associated factor capable of reducing the nodule count.

The impact of reduced illumination as a consequence of shading on nodulation was documented by Adelusi and Aileme (2006); Basu et al. (2025); Abebe et al. (2025); and Mandić et al. (2020).Light quality was stated as a possible factor that could affect cowpea nodulation. Higher illumination levels generally lead to increased nodulation by affording the plants with sufficient photo energy required for photosynthesis to produce the resources required for gall cell (nodule) formation, which in turn hosts the associated bacteria. The light quality is also relevant in the process. The blue and red wavelength bands are more beneficial for nodulation than the others. The direct effect of high light intensity can also lead to high temperature that can result in a decrease in nodule production in cowpea.

vi) Relative Growth Rate (RGR) g g-1week-1.

The interaction of cowpea cultivar and sowing date influenced relative growth rate in inter-cropping, probably due to the acquired physiological and developmental traits of the individual varieties. This may couple with the way these traits interact with the environmental conditions offered by different sowing dates. Essentially, certain varieties may be more adaptable or susceptible/vulnerable to specific sowing dates, which may facilitate enhanced development, thus leading to faster and huskier growth when planted at the optimal time.

inter-cropping as a farming phenomenon can possibly influence the relative growth rate of cowpea via diverse mechanisms. Specifically, a taller component crop in the mixed culture is capable of reducing the quality and quantity of solar income to cowpea, thus impeding its growth and subsequent development. while a later sowing date might modify this shading effect. However, inter-cropping can further afford welfare like improved soil fertility and weed repression.

As an acquired genetic trait, cowpea cultivars differ in their growth habit, maturity time, and tolerance/adaptations to environmental stresses like heat or drought. These factors affect their responses to inter-cropping with other crop species and the timing of their sowing. The timing of sowing appreciably impacts on the availability of resources like H_2O, nutrients, and solar income. It also regulates the magnitude at which they compete and thrive for survival with their associated counterpart/species in the mixed culture. The late-sowing date for cowpea might be less favourable for some varieties, conceivably leading to a reduced growth rate due to increased competition.

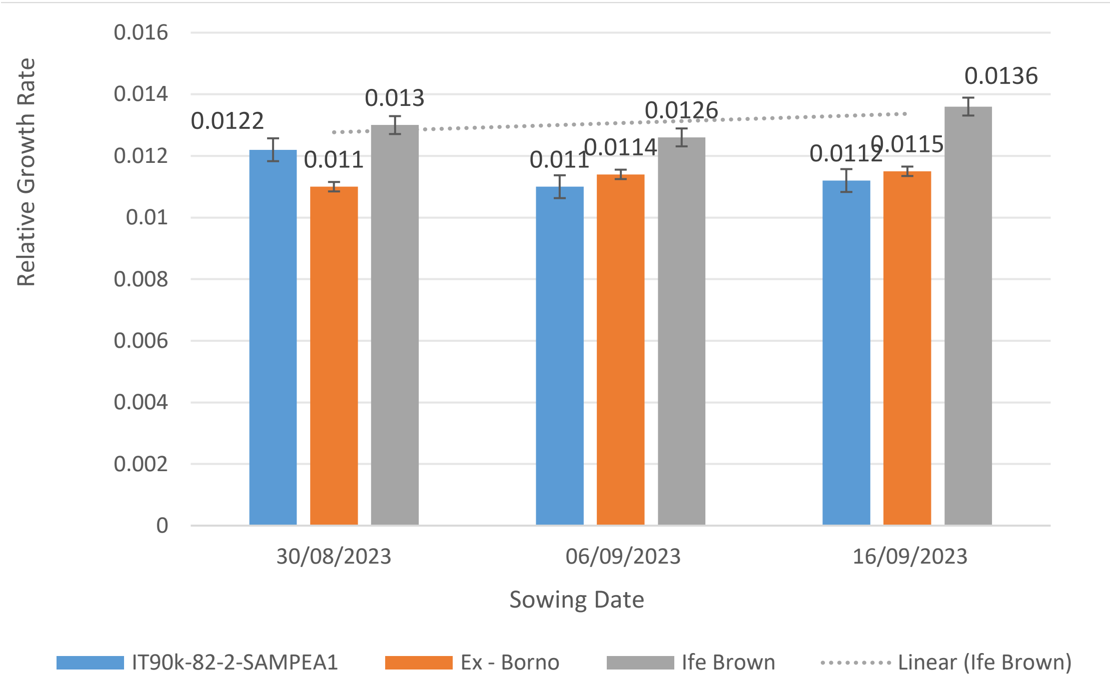

Figure 5b:Effect of Interaction of Variety x Sowing Date on Relative Growth Rate of

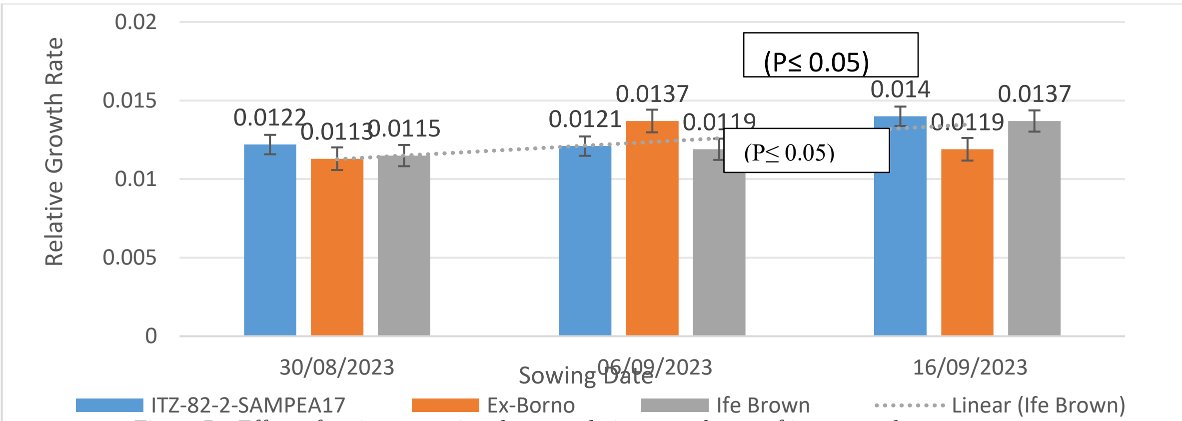

Figure 5a: Effect of variety x sowing date on relative growth rate of intercroped cowpea at Iloffa

vii). Net Assimilation Rate (NAR) gm^{-2} day^{-1}

There are 2 groups of treatment interactions (variety × sowing date) in which the means are not significantly ($P \leq 0.05$) different at location 1 (figure 6a). ITZ-82-2 SAMPEA17 x 13/09/2023, Ex-Borno x 06/09/2023 and Ife Brown x were not significantly ($P \leq 0.05$) different in their NAR. Meanwhile, they all had the highest NAR. At location 2 (figure 6b) there were 3 groups of treatment interactions (variety × sowing dates) with means that were not significantly ($P \leq 0.05$) different from one another. Ex Borno × 06/09/2023 gave the highest RGR. The result agrees with Nwofia et al. (2018). The net assimilation rate (NAR) of cowpea was appreciably influenced by the variety × sowing date, though not exclusive of other environmental elements, including edaphic conditions. Specifically, individual varieties exhibit varying responses to different planting dates, leading to differences in NAR.

For instance, some varieties, due to diverse genetic predispositions that influence their photosynthetic efficiency and, consequently, their assimilation of dry matter, may be more adapted to planting on certain days (with different regimes of temperature and moisture, solar income and pest/disease prevalence.)

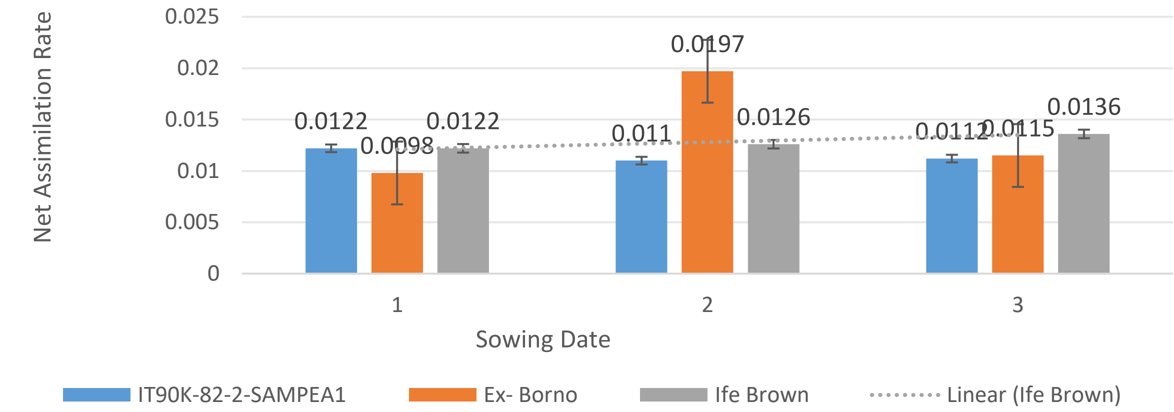

Figure 6b: Effect of Variety x Sowing Date on Net Assimilation Rate of Intercroped Cowpea at Iloffa

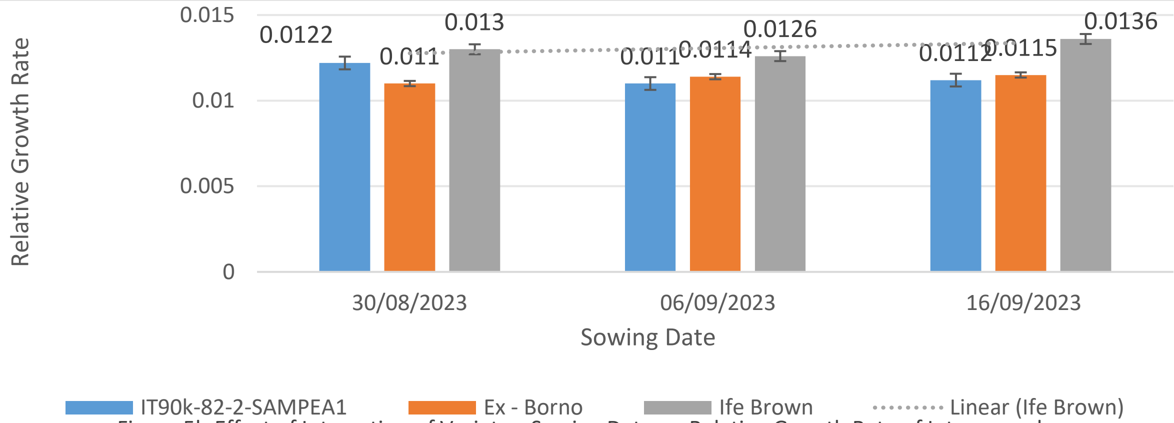

Figure 5b:Effect of Interaction of Variety x Sowing Date on Relative Growth Rate of Intercroped Cowpea at Offa

On a particular date during the season, the prevailing weather conditions may translate to an increase in NAR. It is thus obvious that a variety that is highly sensitive to temperature stress might have a lower NAR when planted during the hotter months compared to a variety that is more heat-tolerant. Another variety may be a more efficient utiliser of H_2O and so may acquire a higher NAR when established during periods of moderate to heavy rainfall compared with a cultivar that is possibly not drought tolerant.

g. Grain Yield (kg/ha)

There are 5 groups (variety × sowing date) of treatments in which the means were not significantly ($P \leq 0.05$) different from at location 1 (figure 6a). The interactions Ife brown × seed sown on 13/09/2023, Ife brown × seed sown on 06/09/2023 and Ex Borno × seed sown on produced the highest grain yields (of 1109, 1081.8 and 1106 kg/ha) that were significantly ($P \leq 0.05$) similar. At location 2 (figure 6b), there were 3 groups of treatments (interactions) in which the means were not significantly different from one another. The highest yields were recorded from the interactions of Ife Brown and Ex-Borno with all three sowing dates (30/08/2023, 06/09/2023 and 13/09/2023).

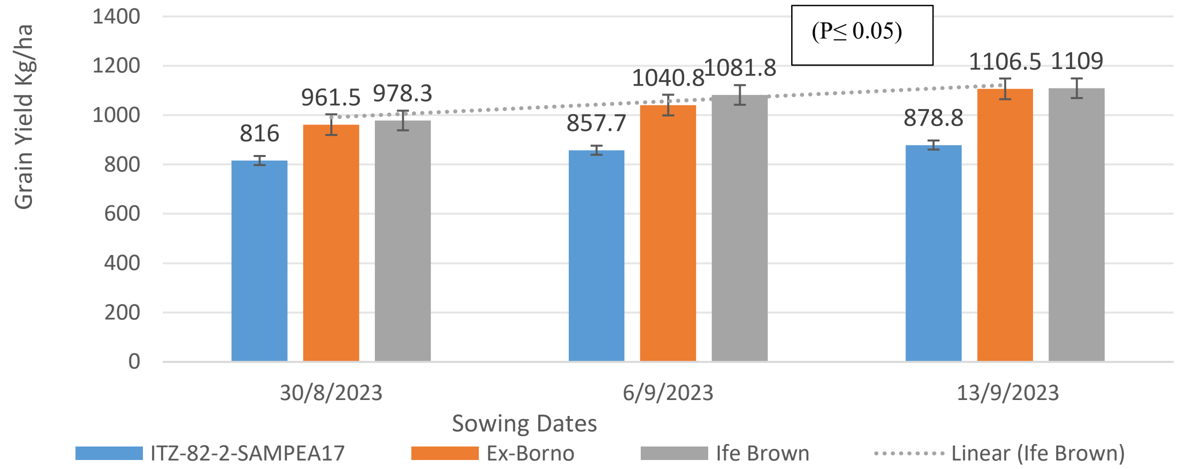

Figure 7a: Effect of variety x sowing date on grain yield of copea

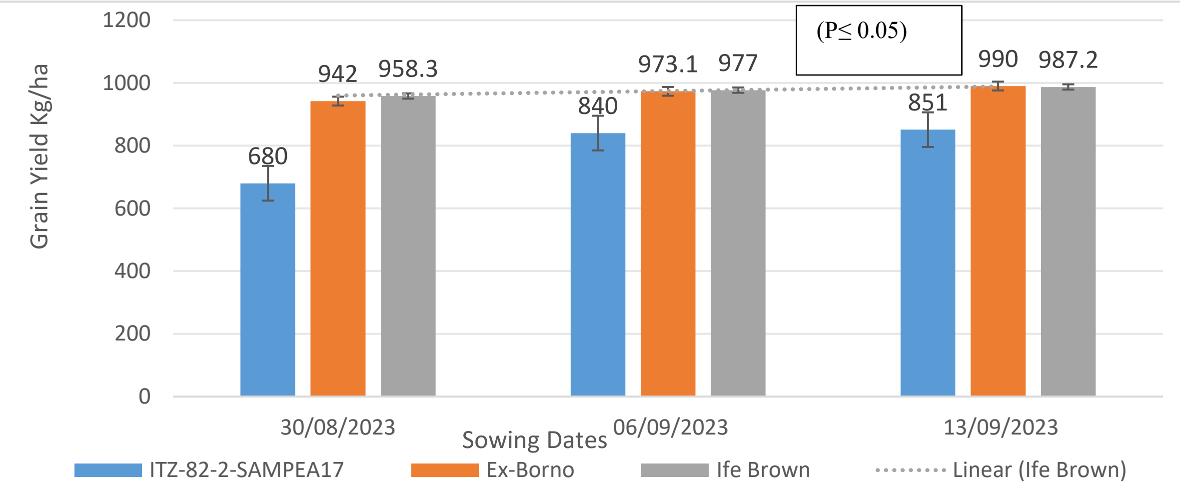

Figure 7b: Effect of variety x sowing date on cowpea grain yield

The treatments with grain yields ranging from 990 to 942 kg/ha were not significantly different from one another ($p \leq 0.05$). The results from the two locations consistently followed a similar trend but with a generally lower yield from location 2.

The result from the present trial is consistent with Goa et al. 2022; Petu-Ibikunle et al. 2024; Kusi et al. (2025).

Variety × sowing date increased grain yield, probably because different cultivars respond uniquely to different sowing dates and environmental conditions as well. Some cultivars were possibly more adapted and responsive to early planting, while others accomplished better when sowing was delayed. This interaction of variety × sowing date, as explained by Gumede et al. (2023), can significantly influence the timing of flowering and maturity (cultivars have varying degrees of sensitivity to day length, which is a key factor influencing flowering time). Some varieties might be more sensitive to photo-period and may not flower or mature optimally if planted too early or too late, and overall seed yield via the modification of the crops' environment by the dynamics of the inter-cropping.

The length of the growing season and variations in environmental conditions during seed development, according to Atakora et al. (2023), may also affect grain characteristics. Cultivars might have different sensitivities to these prevailing factors, thus leading to variations in yield. Cultivar can also interact with sowing date to impact the prevalence of cowpea diseases and pests and the crops' susceptibility and vulnerability to biotic stress. Some cultivars might be more susceptible to certain diseases or pests if planted at a particular time, which can impact yield.

Conclusion

The On-Farm Adaptive Research methodology achieved a simultaneous production and adoption of introduced farming technology by the end users, which in this case are the farmers in the consultative group. The specific genotype responses to environmental conditions and the timing of key physiological processes like flowering, dry matter assimilation and seed development. The interaction highlights the relevance of bearing in mind cowpea variety and planting date in inter-cropped cowpea husbandry for optimal grain yield. Sowing cowpea early or late can thus impact the timing of flowering caused by variations in the seasonality of the (environmental) factors. The consequent phenology responses, especially the time of flower initiation in different varieties and the plant height of inter-cropped cowpea, were reflected in response to the interaction of variety and sowing date. Two out of the tested varieties (Ife Brown and Ex Borno) interacted with late sowing in August or early sowing in September to give the highest grain yield. Having conducted the research as an on-farm adaptive research (with the full involvement of the farmers). The farmers' awareness and knowledge of the possibility of adopting a mixed-culture/inter-cropping farming system of cowpea-maize will be of immense asset in revolutionising the status of the wet savannah zone to another major cowpea food basket in Nigeria.

Recommendation

Based on the present findings, two cowpea varieties (i.e., i. Ex Borno, a variety known to have been bred for adaptations to the semi-arid ecology, and ii. Ife Brown, which, according to Porbeni & Fawole (2018), is well-adapted to the Derived Savanna and Forest Zones of Nigeria). The best sowing date for the recommended varieties is 13/09/2023.

Author's Contribution

Petu - Ibikunle A.M. The agronomist in the project was saddled with the responsibility of designing the experiment. Handled the field practicals, data collection and data analysis and report writing.

Shanni B.B., the irrigation engineer. He was involved in the design of the experiment, where he functioned as a climate change expert. He was an active participant in funding the project. He was part of the supervisor team during data collection.

Aliyu, M. The soil scientist in the team was helpful in translating the implication of the soil fertility and reactions on the crops' performance.

Alawode Y. O. The plant breeder is in the team. The specialist in the selection of cowpea varieties in relation to appropriate sowing dates and locations. She played an active role in the translation of effects of growth hormones and other molecular elements in plant phenology.

v. Tenebe V.A. is a farming system agronomist in the team. He functioned as the advisory consultant in the design and execution of the project.

Conflict of Interest. The authors agreed to all the claims in the report and showed no conflict of interest.

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