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Cowpea Response to Organic Manure and Adaptability to Derived/Wet Savannah Ecological Zone

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Abstract
This trial was carried out on two sites during the rainy season of the year 2022. The main objective was to introduce a well-adapted cowpea variety to the wet Savannah ecology. To achieve simultaneous research, technology transfer, and adoption, three contact farmer's fields in each location were used for the experiment and represented 3 replications. The trial was conducted as a 4×3×2 experiment factorial design, with treatments assigned to the plots in a Randomized block design. Cowpea varieties were the first, the second factor was sowing date, and the third factor was sources of N_2 (i Compost manure & ii, rhizobium inoculated seed). To achieve organic production standards, Tobacco leaf extract was used for pest control, rhizobium seed inoculation, and compost manure was used in place of starter N_2. Manual weeding was also used instead of chemical weed control. Cowpea cultivar/Ife Brown× sowing date (30/09/2022) recorded the highest nodule count. Some of the other various growth and development parameters estimated in the trial resulted in the highest grain yield of 1043.1kg/ha. The use of inoculated Ife Brown cowpea seeds to be sown on 30 /09 was recommended for the wet Savannah zone of Kwara State.
Keywords: Cowpea variety, Wet Savannah ecology, sowing date, Rhizobium inoculated seed, Organic production, Grain yield

Introduction

Cowpea is drought tolerant and as a result, it has the potential of thriving in situations of prevailing moisture stress due to low rainfall. The crop, according to Petu-Ibikunle *et al*. (2010), can perform reasonably well on soils with inherently poor nutrient status where many other crops would not survive. Ajetomobi & Abiodun (2010) reported that a suitably distributed rainfall value of 450 mm per year is adequate/optimum to yield between 1 - 4 tonnes/ha of cowpea grain. Despite the reported potential, cowpea yields are still generally low on arable fields compared to other grains, especially, cereal crops in Nigeria.

Although the International Institute for Tropical Agriculture (IITA) is present in all the ecological zones of Nigeria, one can not ascertain that enough coverage has been recorded in the research on cowpea production. Mohammed *et al.* (2021) reported that cowpea yield as low as 200 - 400kg/ha is still commonly recorded from farmers' fields. The reasons for the reduced grain yield of cowpea can be traced to some field production constraints including pests and diseases (Zahra *et al*., 2019); Olawale & Bamaiyi, 2023), unfavorable environmental conditions (Ibrahim, *et al*., 2021) and poor adoption of best agronomic practices (Fery, 2002; Tony *et al.*, 2014, & Agwu, 2004).

Cowpea is an inter-regional (north to south) trade commodity in Nigeria, primarily because the bulk of cowpea production takes place in the northern part of Nigeria. Production is supported by relatively drier weather, which does not suit the thriving of cowpea disease-causing pathogens. (Sabo, 2015).

The general inflation in Nigeria, recently imposed by the increase in the pump price of petroleum, has simultaneously resulted in the high cost of North-South transportation of cowpea. The problem is further compounded by the geopolitical/religious insurgency and kidnapping of farmers in the field. These have further inflicted production constraints on cowpea farmers (Bojan *et al*., 2020; Belgrade *et al*., 1974 and Ezenekwe & Uzonwanne (2020). The result of climate alteration (due to global warming) on agricultural productivity is not an issue that can be overemphasized. It is no longer reliable to utilize data or information obtained from weather predictions based on previous knowledge, experience, and occurrences. This has necessitated an investigation into new production strategies of agronomic practices (such as seed technology, sowing date, and fertilizer management strategies) that would favorably combine with the prevailing climatic conditions preceding climate change.

Over the years, efforts have been persistent in an attempt to improve and increase Cowpea field performance and grain yield. The advance focused on conventional agronomic practices, which entailed the adoption of best practices via seed technology, the use of inorganic pesticides, and the application of starter N with basal application of P_2O_4 (Lal, 2009). These past interventions are being termed to be short of best practices standards. The use of starter nitrogen fertilizer on cowpeas according to Mohammed (2021) contributes to the production of greenhouse gas (N_2O), P_2O_4 is not easily mineralized or fixed as a result it may not in reality be available for crop use during the critical period of need (Perez, *et al*., 2007, & Pablo *et al*., 2023). The use of Inorganic chemical substances eventually results in the contamination of the food chain and pollution of the general ecosystem (Tudi *et al.,* 2021).

According to Lambot (2002), Cowpeas used to be regarded as a mere delicacy used as a protein supplement in the diet of the poor who could not afford animal protein, but have in recent years, turned out to be a staple food for both the rich and the poor. According to Akibonde & Maredia, (2011), this is not just because of its nutritional content which is almost balanced in both Protein and carbohydrate, but the sky-rocketing prices of Animal sources of protein (Meat, Milk, egg, and fish) has further excited the thought and need to boost cowpea production in an attempt to cope with the teeming population and the looming danger of food insecurity in Nigeria.

The present study is therefore conceived to test some cowpea varieties for suitability and adaptability to the derived/wet savanna of Nigeria. This will be further supported by popularizing and introducing the best-adapted variety to the farmers in the zone. Attempts would also be made to investigate some agronomic practices that would minimize the contribution of cowpea production to greenhouse gases/global warming(Ayalew & Yoseph, 2022). Attempts would also be made to produce cowpeas under organic conditions to minimize Pollution and contamination of the food chain and the ecosystem.

Materials and Methods

1. Description of the experimental site

The research was conducted in bi-location at Kwara State at Ilofa (Location 1) and Offa (Location 2).

a. Location 1 Iloffa, Oke Ero, Kwara State, Nigeria; 5° 8' 32" E · 8.09343,5.14233 · Aw: Tropical savanna, wet · 2337655 · The mechanical analysis of the soil shows a percentage particle size distribution of Sand (72) and clay (12) silt (16), according to Petu-Ibikunle *et al*., (2022)

b. The soils were moderately acidic to slightly acidic (pH 5.45). The macronutrients (N,32 P38 k 0.17 PPM), organic carbon (0.84), and CEC of the soils were generally low with high base saturation (6.60), according to Petu-Ibikunle *et al*. (2022)

b. Location 2 Offa the second location, Latitude 8° 8 56" N, Longitude 4° 43' 14" E. with the climate type Tropical Savanna Wet. The mechanical analysis shows a proximate analysis of Sand (75), clay (15) silt (10). The soils were moderately acidic to slightly acidic (pH 5.2). The macronutrients (N28, P26, K 0.15PPM), organic carbon (OC), and CEC of the soils were generally low with high base saturation (5.1 cmol/kg soil).

c. Rainfall pattern in Kwara State?

The zone Kara state experiences up to 101.45 millimeters (3.99 inches) of rainfall in 148.38 days annually. The monthly mean temperature ranges from 22 °C during nighttime to 33 °C in the daytime. (NIMET, 2023)

2) Land preparation

a. Bush clearing started during the short dry season (otherwise called August break) of the 2022 cropping season. The vegetation containing weeds and shrubs was manually removed (using a cutlass). Rubble was gathered and packed away from obstructions on the farmland.

b. *Plot demarcation* plots were demarcated into plot sizes of 4m x 2 m. Hoes were then used to pulverize into friable seed beds. A total of 24 plots were obtained.

3. Experimental design and treatment allocation

A 4×3×2 factorial design was adopted to obtain gross treatment combinations of 24 plots. The treatments were replicated three times, with each contact farmer's field standing as one replication.

a. The main plot consisted of Four Cowpea Varieties

(i) IT-16
(ii) IT-18
(iii) IT-04K-321-2 1460
(v) Ife brown

b. The second factor is three sowing dates
i).16/07/2022,
(ii).23/08/2022 and
(iii).30/08/2022.)

c. The third factor represents two sources of nitrogen.
i) Uniform application of Poultry compost manure at 2.4 kg pa hectare.
ii) Rhizobium inoculated seed without compost manure application.

Compost manure was prepared according to the procedure of Chetan (2022), and rhizobium inoculum was obtained from IITA.

d. Seed Planting

Seeds were sown based on three seeds per hill, with thinning done at 7 days after sowing. A 50cm x 20 cm spacing was adopted to obtain a total of 105 plants per hectare. Supply

e. Pest control

tobacco leaf extract was applied (using Tobacco extract nicotine, d-limonene, pyridine, and indole with the aid of a Knapsack sprayer. Three applications were done first at 50% blooming, second at 100% blooming, and third at the pod maturity stage.

f. Weeding

Weeds were manually removed (with hoes) at 3rd and 6th weeks after sowing to reduce competition. The wedding also gave an advantage of further working the manure into the soil and achieving earthing up at the base of the plant, which was initially planted on a flat(root aeration, and increased soil temperatures)

4. Data collection

a. Nodulation.

Frame quadrants (50cm x 50 cm) were thrown on each plot, selection of 15 plants that were captured within the quadrant were uprooted for nodule count. The roots of uprooted cowpea plants were rinsed in water, and the nodules attached roots were enumerated using a hand lens to aid clarity.

b. Days to 50% flowering

Daily observations were made to track the day when 50% of the cowpea plants on each plot would have initiated flower formation.

c. Days to Maturity

Daily field observations were made on each plot to observe how long it would take the cowpea plant to record ±5plant to simultaneously complete flower formation and pod formation.

d. Pod count (Per Plant).

Pods number per plant was determined based on the method described by Egho (2009). A 1 x 1 Meter quadrant was thrown on each plot to mark the plants that were trapped within the quadrant arena. The number of pods was then divided by the number of cowpea plants. (Number of pods /number of plants = Number of Pods pa stand of cowpea).

e. Grain yield (kg^{-ha})

Pods of cowpea were manually harvested when the pods started turning brown and drying. The harvested pods were sun-dried until the pods started to break. for five days. The drying period lasted for five days.

Threshing was achieved by beating the bags containing the pods with a stick. The beating/hitting of the bags was followed by winnowing to separate the chaff from the grains. Weighing was done using an electronic weighing machine (model)

5. Data analysis

The collated information was statistically analyzed, using the Analysis of variance (ANOVA) at a 95% confidence interval as the statistical tool. Treatment means of variables that were significantly different at (P≥0.05) were separated using the least significant difference (LSD) at 0.95% (P≥0.05) confidence interval.

Results and Discussion

a) Effect of V×N on days to attain 50% flowering in cowpea.

Attaining 50% blooming was significantly (P≥0.05) influenced by cultivar×nitrogen (Figure 1). This result was not the same at Location 2, where variety×source of nitrogen did not reduce days to 50% flowering in Cowpea. Amongst the four varieties tried, only IT-16 and IT-18 recorded significantly different (P≥0.05) days taken to attain 50% flowering from one another in response to the treatments. IT-18 recorded 46.9 from seed inoculation as the earliest days to 50% flowering relative to other treatments. The conflicting results from the locations may also mean there is the possibility of location/environment interaction, as reported by Sato *et al. (2022), where a* cultivar x Nitrogen (interactions) on plant rate of growth was observed. This result was ascribed to the possible existence of inter-location microclimate prevalence. Meanwhile, the application of compost manure (called bio-fertilizer) in the report of Singh *et al*. (2000) is possibly an unintentional introduction of some species of free-living N-fixers and mycorrhizal fungi to the root zone. These organisms are capable of fixing N_2, and together with an enhanced, efficient root performance of cowpea. Verma *et al*. (2020) explained in support of these findings that rhizobium tends to protect crops against ethylene stress by utilizing the crop ethene precursor chemical 1-aminocyclopropane-1-carboxylate (ACC). The enzyme activator ACC deaminase facilitates the breakdown of ACC to ammonia and –ketobutyrate. The action minimizes ethylene output in crops undergoing stress. This is suggested as the reason why most of the varieties appeared not to have responded to either of the two sources of nitrogen, or the reason why they recorded a similar response. Varietal responses to N sources might mean different roots manifest by the two varieties to various soil-root associations created by the N sources.

b) Effect of V×N on the Pod count of cowpea

The pod count of cowpeas was significantly (P≥0.05) increased by **V× N** at the two experimental sites. (Figures 2a and 2b). From location 1, the highest number of pods was recorded from IT-04-321-21460 with 67.2 and 64.3 pods respectively for Rhizobium inoculated seed and compost manure. While at location 2, there was a slight inconsistency with the results observed at L1, where the lowest pod count was recorded from IT-16, as the other three varieties recorded higher pod numbers (from seed inoculation and manure application) that were not significantly (P≥0.05) different. It is important to note at this point that Pod yield (count) is sometimes a function of the number of pollinated flowers that were able to make it to the pod initiation and pod filling stage. The interaction of variety and nitrogen (source) may thus be assumed to translate whether any of the varieties benefited from a sort of immunity or protection from one N source better than the other to afford the enhanced flower protection and the subsequent flower formation. Supported by Kandil & Özdamar (2023). The pod count of cowpeas was increased by the interaction of Nitrogen × variety (Faye, 2024). Fernandez and Miller (1985) suggested that pod count per plant was a main yield component that could be influenced by treatments (and treatment interactions) to be responsible for variability in cowpea yield. The differential genotypic responses to N source may be explained by Jia *et al.* (2021) report that at different nitrate concentrations resulting from the activities at the root zone, the genotype's response to photo-period via flowering responses was influenced by insufficient nitrate levels being sub-optimal for flowering. This signifies that nitrate doubles as a nutrient source for development and as a communication material for floral induction, which depends on the quantity of N resources the source of nitrogen is releasing or supplying.

c) Effect of V×N on the nodule count of cowpea

Nodulation was significantly (P≥0.05) influenced by variety × nitrogen source from locations I &2 (figures 3a & 3b). At location 1, Ife Brown recorded the highest population of 48.1 and 49.6, respectively, for seed inoculation and compost manure application. Similarly, at Location 2, the highest nodule counts of 45 and 47 were the highest from Ife brown, respectively, for seed inoculation and compost manure application. Genotypes/varieties according to Thalukanyo *et al*. (2020) respond differently to strains of bacteria used for inoculation; the treatment interaction is expected to significantly influence nodulation. Wang, *et al*. (1982) expressed that both nodulating and non-nodulating Rhizobium leguminosarum strains (possibly present in compost and capable of establishing various biosynthetic associations with various cowpea genotypes depending on the breeder's objective) produce indole-3-acetic acid which promotes the growth of the plant and plays a crucial role in the production and expansion of root nodules.

d) Effect V×N on biomass yield of cowpea (Kg/ha)

Variety **×** nitrogen source interaction significantly (P≥0.05) increased the biomass production of cowpeas at the two sites (Figure 4a & 4b). At location 1, IT-04-321-21460 yielded the highest biomass of 3741.7 and 3237.06 kg/ha, respectively, for seed inoculation and compost manure. The trend was similar at location 2, with biomass yields of 3264.1 and 3266.3 recorded from seed inoculation and compost manure application. This result shows that individual cowpea genotypes respond distinctly to their interactions with specific nitrogen sources. The work of

et al. (2013) supports and explains the present findings. Some leguminous species, when jointly inoculated with rhizobia and several strains and species of *Bacillus,* showed conspicuous changes in root architecture (of individual genotype), and increased nodulation was observed. Generally, microorganisms, including *B. subtilis,* are known to power plant growth directly by secretion of hormones like auxin, cytokinins, and gibberellins, according to Ali *et al*. (2009); Galaviz *et al*. (2018). The contribution from Meng (2016) explained further that apart from the direct stimulation of plant growth hormones, there is a sidelong production of stress-inhibiting enzymes, siderophore, and P-solubilization that combine to result in distinguished biomass yields of the individual cowpea genotype.

e) Effect of V×N on grain yield of cowpea

Variety **×** Nitrogen significantly (P≥0.05) influenced the grain yield of cowpeas at the two locations (Figure 5a &5b). From location 1, Ife brown recorded the highest grain yield of 1048.4 and 1044.1 from seed inoculation and compost manure application. Similarly, at location 2, Ife brown still recorded the highest grain yield valued at 1042.8 and 1041.1 kg/ha grains respectively for seed inoculation and compost manure application. This result is consistent with the study Lawrence (2017); and Munjonji *et al*. (2015) and also revealed an obvious genotypic alteration in grain production (Genotype × environment interaction (GEI) playing a significant role in determining the desirability or superiority of a genotype, hence the need to evaluate genotype over a wide range of edaphic environment created by various species of both free-living and biosynthetic N_2 fixing bacteria and the subsequent biosynthesis activities/association. Some genotypes are better biological N fixers Lawrence, 2017), and Malik & Sindhu (2011) reported that the enhanced plant growth and development achieved after inoculation could be ascribed to the biosynthesis and secretion of IAA by rhizobacteria. Vargas *et al*. (2017); and Olufajo and Oladiran (2018) further explained that rhizobacteria tend to evoke plant defense reactions against phytopathogens a claim that tallies the earlier record of Singh *et al*. (2020) that bio-fertilisers such as nitrogen fixers increased crop yields through better plant growth by protecting plants from stress and diseases.

Interaction (Variety × Sowing Date)

a) Effect of variety × Sowing Date on Days to 50% flowering in Cowpea

variety x sowing date resulted in a significantly (P≥0.05) reduced number of days taken for cowpea to attain 50% flowering (figure 1a & 1b) in the two experimental locations. The shortest period taken to attain 50% flowering was obtained from vi sowing on 16/09/2022. With about 39 days to 50% flowering. (Disadvantage) The result from location 2 is slightly inconsistent with the trend obtained at location 1. The two locations share in common the longest day (59 and 57) in 50% flowering from the brown variety of Cowpea sown on 30/09/2022. The result means cowpea cultivars took longer to attain 50% maturity when planted in August, while those planted later displayed early maturity. The result is similar to the report from Akande *et al.* (2012). Early flowering of cultivars sown early in the season may not be desirable because of the effect of excess rainfall and the consequences, including pest and Disease prevalence, which may leaf diseases and flower abortion. The delayed flowering recorded by Ife brown at late sowing is consistent with Joscha *et al*. (2024). It was opined that under optimum moisture conditions, crops can flower early. Ife brown sown late is thus expected to have ordinarily been subjected to moisture stress and thus expected to record a delayed flowering due to moisture stress. The interaction of Ife brown(cultivar) and late sowing is thus suspected to have combined/interacted favorably to induce late flowering. Further explanation was that soil resources are components of the environment that interact with the cultivar (Ife brown) to create an optimum condition from the prevailing environmental conditions/weather during sowing that favored early cowpea flowering. Findings from the present study are supported by the report of Nwofia *et al*. (2018), where sowing at different dates influenced flower induction in different genotypes. The distinct days taken to achieve flower induction were attributed to enhanced changes in the photo-periodic disclosure (photo regime) of cowpeas. The various sowing dates possibly fell within or outside shorter days and longer night periods. It might have likewise fallen within or outside a period of less cloudiness. The sowing dates (3 weeks in August) investigated in the present study were marked by distinct variations ranging from the cloudy wet season to the less cloudy dry season, as well as temperature modification (by the prevailing rainfall pattern), which coincides with the phenological (flowering) period of the crops. It was recorded by Takeno (2016) that during the late season, there exists plant Stress-induced flowering, which is a manifestation of an adaptive mechanism to ascertain seed formation even when individual survival under prevailing intense stress is indefinite. This process is under the dominance of various stress-inducing factors and plant signaling substances, including polyamines. This could explain why with late sowing (a period of higher temperature, low moisture, and less cloudiness), a variety like Ife Brown, amongst other varieties, with either seed inoculation or compost manure recorded the most significant delay in flowering. Hadley *et al*. (1983); Jia *et al*. (2021) explained that at varying nitrate concentrations, flowering will respond to photo-period fluctuations, either get impaired or enhanced. A sub-optimal nitrate level becomes sub-optimal for flowering.

A prolonged photo-period enhances nitrate absorption by the root and impedes the efficiency of the nitrate transporter. The reduction in the efficiency of nitrate transporter mutants (which differs amongst genotypes) suppresses the manifestation of the key flowering genes.

This result suggests that the upward ascendance of root nitrate uptake during extended photo-periods contributed to the observed early flowering. This is because of the sensitivity of flowering in response to photoperiodic rhythm by elevated levels of nitrate.

The nitrate level is reduced by either the replacement of nitrate with the assimilation of an intermediate product (like ammonium) or by the dysfunction of the nitrate assimilation pathway. This indicates that nitrate serves as both a nutrient source for plant growth and as a signaling molecule for floral induction during extended photo-periods.

b) Effect of variety × sowing date on pod count of cowpea

Pod count was significantly (P≥0.05) increased by the interaction of variety and sowing date (figure 2a & 2b) at the two locations of the experiment. The pod counts were generally higher from cowpea varieties when shown on 30/09/2022 at the two locations. The slight difference between L1 and L2 is that early sowing on 19/09/2022 also gives an impressive higher pod count with a variety of Ife Brown at the 2 locations. This result is similar to Aliyu *et al.* (2024); Ankrumah *et al*. (2024). Ezeaku *et al*. (2015) & Yesin *et al.* (2014) generalized that the increase in pod yield was likely to be the consequence of specific adaptations of certain varieties to specific environmental conditions obtainable at different sowing dates.

c) Effect of Variety × Sowing Date on Nodule Count of Cowpea

Nodulation at locations 1 & 2 was significantly (P≥0.05) increased by the interaction and variety, and sowing date (Figures 3a and 3b). Ife Brown recorded the highest nodulation of 58 and 59 with Sowing on 16/09/2022. The trend with the 3 sowing dates showed a consistent trend of modulation ranking from the lowest to the highest as 16/08/2022 < 23/01/2022 < 30/09/2022. This implies that modulation increases with decreasing rainfall. An inverse relationship between rainfall and nodulation is thus depicted. A similar observation was recorded by Becker *et al*. (2024). The report of Makgato *et al*. (2020) further explained that strains of Bradyrhizobium are host-specific due to host crop adaptive traits (genotype). The cowpea genotype is possibly bred for adapting to certain environmental conditions like moisture regime (drought resistance or tolerance), temperature regime (ie, heat tolerance), photoperiodicity (Photosynthetic Active Radiation Capturing), and pest and disease resistance/ tolerance. The various adaptations may have a consequence on the subsequent infestation of the root hair of some cultivars by specific strains of bacteria in the process of modulating. The interaction of the sowing date and cowpea variety stresses further the relevance of considering varietal selection with the appropriate sowing date as reported by Ezeaku *et al*. (2015).

d) Effect of variety × Sowing date on DMY of Cowpea

Biomass yield was significantly (P≥0.05) increased in variety × sowing date (Figures 4a and 4b) at the 2 locations. DMY was generally highest (3325 kg/ha) at the two locations. The lowest DMY for all three 3 sowing dates was the least from the Ife brown variety 2000 kg/ha) regardless of the 3 sowing dates. The various cowpea cultivars have distinct genotypes. It is ordinarily expected that their phenotype will be a product of the Genotype + Environment. The individual varieties have inherent traits that would make them adapt to the prevailing environmental conditions. Variety IT-04K-321-21460 recorded the highest DMY at the 3 sowing dates. This result agreed with the findings reported by Agele *et al*. (2017). The variety has a spreading growth habit. And takes 98 days to mature. Bhuvaneswari (2023) stated that cowpeas sown on different dates will show a different biomass accumulation due to sowing date and location interaction. Alemayehu (2022) reported that sowing date × genotype (interaction) can influence DMY. Cowpea cultivars differed in their potential for biomass partitioning from source to reproductive sinks, signaling variations in the efficiency of assimilate utilization for seed production. Specifically, dry matter partitioning was highest in IT-04K-321-2 1460 but did not reflect in seed set efficiencies. And seed yields were highest in Ife brown, which may be attributed to high crop yields under the low soil moisture and high temperatures of the late season, to high assimilate partitioning.

High assimilate partitioning thus signifies a desirable attribute/quality for cowpea varietal/genotype adaptation to the environment of the experimental locations.

These findings align with previous studies by Okpara and Oshilim (2001), Idahosa *et al*. (2010), Agbogidi and Egbo (2012), Nwofia *et al*. (2015) and Ezeaku *et al*. (2015) in which they stressed the importance of genotype as a major determinant that influences both morphological growth and development of cowpea. The effects of environmental alterations due to changing (temperature, light intensity, and water availability) sowing date on plant growth rates (dry matter production) were reported by Ma *et al*. (2020). Vega *et al.(*2000*)*, Duncan *et al.*(1978), and Sato *et al.*(2022) reported the effects of temperature on dry matter production.

e) Effect of Variety × Sowing Date on Grain Yield of Cowpea

The grain yield of cowpeas was significantly (P=0.05) increased by the interaction of variety and some sowing dates (Figures 5a and 5b) at the two locations of the experiment. The highest grain yield (1250 and 1215 kg/ha) was recorded for Ife brown sown on 30/09/2022. This result is consistent with Aliyu *et al*. (2023). Cowpea responded significantly to the variety and time of sowing in sesame, and cowpea intercropped *Cowpea variety interacted positively with the sowing date. The result is also supported by* Asante *et al*. (2001) and Nwofia *et al*. (2018). Elite cowpea cultivars recorded impressive grain yield when sown between mid-June and mid-July without the use of insecticide. On the other hand, the local variety used as a check/control in the study produced higher grain yield when sown in late August, generally resulting in superior crop performance. Notably, certain cowpea varieties exhibit appreciable adaptability and potential for higher productivity. This implies that proper timing and appropriate variety selection (ie, variety x sowing date) enhance optimal cowpea production in the study area. The report of Ankrumah *et al*. (2024) supported the present findings that cowpea lines performed better in terms of grain yield when planted between mid-July without insecticide protection, whereas a local variety included in the study produced higher grain yield when planted between late July and early August.

Late sowing on 30/09/2022 falls within the second rainfall regime (terminal drought situation) between August/September and November. The period is characterized by limiting soil moisture, high soil temperatures, low humidity, and high solar radiation. The results can be explained by the report of Agele & Agbi (2012) that prevailing weather of the early to late-rainy seasons is a critical factor in the processes of determining growth and yield characteristics of cowpeas.

Godson *et al*. (2018) reported that improved genotype and manipulations of sowing dates to late September in the wet tropics will sufficiently minimize the presence of insect pests that could have impaired cowpea podding and invariably increased grain yield. However, Lal (2009) and Hartman *et al*. (2011) reported that optimum planting dates for varieties of crops differ and depend on crop cultivar and the agro-ecology zone. The climate change phenomenon now affects the cropping seasons and farming calendar, leading to wide fluctuations, alterations, and variations in productivity and yield components (Akande *et al*., 2012).

The work of Wallace *et al*. (1991), Saini, & Westgate (1999), explained further that the morphology and physiology of legumes are highly dependent on genetic makeup and environmental factors (like soil moisture regime, soil fertility status, air and soil temperature, and day length amongst others), which enables the crop to optimize the use of natural resources (nutrients, water, CO_2 and PAR) and the variations of which are functions of sowing dates and genotype of the crop.

Conclusion

Cowpea varieties (genotype) in the present study were observed to exhibit traits when exposed to different environments (phenotype×environment = genotype). The crop environment in this study was defined as sowing dates, which were expressed as microclimate. (photo-period, temperature regime, moisture regime, and soil physical and chemical characteristics) During seasonal changes. There was also an established relationship between the interaction of cowpea genotype/variety and the source of Nitrogen (compost manure and Seed inoculation with rhizobium bacteria). It was observed that applying compost manure to cowpeas may result in some unintentional soil and root inoculation with some free-living and bio-synthetic N-fixers. The interaction of Ife brown variety x source of nitrogen (inoculated seed and compost manure) resulted in the highest grain yield. The two sources of N_2 did not result in a significantly different cowpea grain yield of Ife Brown. The highest grain yield of cowpea relative to other varieties x N was from Ife brown. Cowpea cultivar responded to both seed inoculation and application of compost manure. The interaction of variety and sowing date (30/09/2022) produced the highest yield from Ife Brown. Based on the findings from this study, it is recommended that the Ife Brown variety of cowpea should be planted in late August (30/09) in the wet Savannah zone of Kwara State.

References

Abudulai, M., Seini, S. S., Haruna, M., Mohammed, A. M., and Asante, S. K. (2016). Farmer participatory pest management evaluations and variety selection in diagnostic farmer field Fora in cowpea in Ghana. *African Journal of Agricultural Research,* 11: 1765 - 1771.

Abudulai, M., Seini, S. S., Haruna, M., Mohammed, A. M., and Asante, S. K. (2016). Farmer participatory pest management evaluations and variety selection in diagnostic farmer field Fora in cowpea in Ghana. *African Journal of Agricultural Research,* 11: 1765- 1771.

Agbogidi, O.M., Egho, E.O., (2012). Evaluation of Eight Varieties of Cowpea (*Vigna Unguiculata* (L.) Walp) in Asaba Agro-Ecological Environment, Delta State, Nigeria. European *J. Sustain. Dev*., 1: 303-314.

Agele, S.O. and Agbi, M.A (2012). Growth and Yield Responses of Selected Cowpea (*Vigna unguiculata* L. Walp) Cultivars to Weather and Soil Factors of the Sowing Seasons. *Res. Rev. Bio Sci.*, 7: 265-276.

Agele, S.O., Oyewusi, I.K., Aiyelari, O.P. and Famuwagun, I.B (2017). Dry Matter Production, Biomass Partitioning and Seed Setting Efficiency in Early- and Late-rainy Season Cowpea in the Rainforest. Agroecology of South-West Nigeria. International Journal of Botany, 13:115-125. https://scialert.net/abstract/?doi=ijb.207.115.125.

Agwu, A. E. (2004). Factors affecting adoption of improved cowpea production technologies in Nigeria. *Journal of International Agriculture and Extension Education*, 11(1):81-88.

Ajetomobi, J, Abiodun, A. (2010). Climate change Impacts on Cowpea Productivity in Nigeria. *African Journal of Food Agriculture Nutrition and Development,* 10(3):2258-2270.

Akande, S.R., Olakojo, S.A., Ajayi, O.F., Owolade, J.A., Adetumbi, O.N., et al. (2012). Planting Date Affects Cowpea Seed Yield and Quality at Southern Guinea Savanna. *Nigeria Seed Technology*, 51-60

Akibonde, S. and Maredia, M. (2011). Global and regional trends in production, trade, and consumption of food legume crops Department of Agricultural, Food and Resource Economics, Michigan State University. (pp. 83). https://doi.org/10.22004/ag.econ.136293.

Alemayehu, A.L., Mulisa, F.D. and Kedija, A.S. (2022). Morphological Characters, Dry Matter Production, and Nutritional Quality of Cowpea (*Vigna unguiculata L.*) as Influenced by Genotype and Environment. *Indawi Advances in Agriculture*, Article ID 6672801. https://doi.org/10.1155/2022/667280

Ali, B., Sabri, A.N., Ljung, K. and Hasnain, S. (2009). Auxin Production by Plant Associated Bacteria: Impact on Endogenous IAA Content and Trowth of Triticum aestivum L'Lett. *Appl. Microbiol.*, 48 (5): 542-547.

Aliyu, A., Yusuf, A.A. and Abaidoo, R.C. (2024). Response of Grain Legumes to Rhizobia

Inoculation in Two Savanna Soils of Nigeria. *African Journal of Microbiology Research*, 7(15):1332-1342.

Aliyu, I., Dugje, I.Y., Kamai, N. and Usman, A. U. (2023) Effects of Cowpea (*Vigna unguiculata (L.) Walp*.) Varieties and Sowing Dates on Performance of Cowpea in Sesame and Cowpea Inter-cropped in Sudan Savanna, Nigeria*. Journal of Agricultural Economics, Environment and Social Science,* 9(2):47-59.

Ankrumah, E. and Yahaya, S.U. (2015): Effects of Nitrogen, Phosphorus and Inoculation on the Yield Components and Grain Yield of |Soybean (*Glycine max* (L.) Merrill). *Savannah Journal of Agriculture*,10 (1): 35 – 41.

Ayalew, T., & Yoseph, T. (2022). Cowpea (Vigna unguiculata L. Walp.): A choice crop for sustainability during the climate change periods. *Journal of Applied Biology and Biotechnology*, 10(3):154–162. https://doi.org/10.7324/JABB.2022.100320.

Becker, J.N., Grozinger, J., Sarkar, A. *et al.* Effects of cowpea (*Vigna unguiculata*) inoculation on nodule development and rhizosphere carbon and nitrogen content under simulated drought. *Plant Soil*, 500, 33–51 (2024). https://doi.org/10.1007/s11104-023-06051-1.

Belgrade, C.K. and Norman, K.W. (1974). Increasing Energy Price: The Impact on Transportation Cost and the Regional Location of Agricultural Production. Proceedings Annual Meeting. (Western Agricultural Economics Association), 47:176-83. http://www.jstor.org/stable/43915552.

Bhuvaneswari. P., Hemalatha, S., Tirumala, R.S., Leelavathy, G.P. and Chandrika, V. (2023) Effect of Organic Nutrient Management on Quality Parameters and Yield of Fodder Cowpea Varieties. *International Journal of Environment and Climate Change,* 13(12): 614-619.

Bojan, S., Mladen, P., Zorica, V. (2020). The Impact of Transportation Cost on Economic Performance in Crop Production, 67(3):683-697.

Boukar, O., Fatokun, C. A., Huynh, B. L., Roberts, P. A. and Close, T. J. (2016). Genomic Tools in Cowpea Breeding Programs: Status and Perspectives. *Frontiers in Plant Science*, 7:757. https://doi.org/10.3389/fpls.2016.00757.

Chetan, G., Palak, B., Harshita, A. and Manjeet, S. (2020) Parametric Study of Compost Preparation from Organic Matter: *International Journal of Advanced Study and Research Work* (2581-5997)/ Special Issue ICROIRT- 2020/September 2020. DOI:10.13140/RG.2.2.19925.65766.

Duncan, W.G., McCloud, D.E., McGraw, R.L., and Boote, K.J. (1978). Physiological Aspects of Peanut Yield Improvement. *Crop Sci*., 18: 1015-1020.

Egho, E.O. (2009). Control of Major Insect Pests of Cowpea (Vigna unguiculata (L.) Walp) Using Conventional and Non-Conventional Chemicals. A PhD Thesis submitted to the Department of Agronomy, Delta State University, Asaba Campus. 224p.

Ezeaku, E., Mbah, B.N. and Baiyeri, K.P. (2015). Planting Date and Cultivar Effects on Growth and Yield Performance of Cowpea (*Vigna unguiculata (L.) Walp*). *African Journal of Plant Science*, 9(11):439-448.

Ezenekwe, U.R. and Uzownwanne M.C. (2020). Impact of Transportation Cost on Prices of Consumables in Anambra State. *Journal of Economics Studies (JES)* 17(1):14-32

FAO (2019). Soil Fertility Management in Support of Food Security in Sub-Saharan Africa. Food and Agriculture Organisation of the United Nations, Rome, 2001.

Faye, A., Augustine, K., Obour, T., Moriaque A., Zachary, P., Stewart, D., Min, P.V. Vara, P., Yared, A.(2014). Dual-purpose Cowpea Grain and Fodder Yield Response to Variety, Nitrogen–Phosphorus–Potassium Fertilizer, and Environment. *Agrosystem, Geoscience and Environment*, 7(1): e20459

Fernandez, G. C. J. and Miller, J. C., Jr. (1985). Yield component analysis of five cowpea cultivars. *Journal of American Society of Horticultural Science*, 110 (4): 553–554. https://doi.org/10.21273/JASHS.110.4.553.

Fery, R. L. (2002). New opportunities in *Vigna*. In: J. Janick and A. Whipkey (eds.), Trends in new crops and new uses. ASHS Press, Alexandria, VA. pp. 424–428.

Galaviz, C., Lopez, B. R., Bashan, L. E., Hirsch, A. M., Maymon, M., and Bashan, Y. (2018). Root growth improvement of mesquite seedlings and bacterial rhizosphere and soil community changes are induced by inoculation with plant growth-promoting bacteria, and promote restoration of eroded desert soil. *Land Degrad. Dev.* 2018:2904. doi: 10.1002/ldr.2904

Gillett, A.G., Crout, Stokes, D.T. Sylvester-Bradley, v, and Scott, R.K. (2001). An Approach to Modelling the Effect of Environmental and Physiological Factors Upon Biomass Accumulation in Winter Wheat. *J. Agric.Sci*.,136:369-381.

Godson, E.N., Chinenye, R.O. and Emmanuel, U.M. (2018). Genotype by Planting Date Effects on Cowpea in Humid Fringes, Southeast Nigeria. *Breeding and Biotechnology*, 6:95-108. https://doi.org/10.9787/PBB.2018.6.2.95.

Hadley, P., Roberts, E.H., Summerfield, R.J., and Minchin (1983). A quantitative model of reproductive development in cowpea [*Vigna unguiculata* (L) Walp.] about photoperiod and temperature and implications for screening germplasm. *Ann. Bot*., 51: 531-543.

Hartman, GL., Ellen, DW., and Herman, TK. (2011). Crops that feed the World 2. Soybean - worldwide production, use, and constraints caused by pathogens and pests. *Food Sec*. *3*:5-17

Ibrahim, M., David, A.A., Mshelia, J.S., John, A.B., Sunday, B., and Stephanie, S. B.(2021). Effect of climate variation on the yield of cowpea (*Vigna unguiculata*), *African Journal of Agricultural Research*,17(3):456-462. DOI: 10.5897/AJAR2020.14960

Idahosa, D.O., Alika, J.E. and Omoregie, A.U. (2010). Genetic Variability, Heritability and Expected Genetic Advance as Indices for Yield and Yield Components Selection in Cowpea (Vigna unguiculata). *Academia Arena,* 2: 22-26.

Janardan, Y.., Verma, J.P. (2014) Effect of Seed Inoculation with Indigenous Rhizobium and Plant Growth Promoting Rhizobacteria on Nutrient Uptake and Yields of Chickpea (*Cicer Arietinum* L.) *European Journal of Soil Biology,* 63: 70-77

Jia, Y.Y., Wen, H.T., Miao, Z., Qing, Y. Zhu, Wen, X.D. and Chong, W. (2021). Improved Plant Nitrate Status Involves Flowering Induction by Extended Photoperiod. Frontiers in Plant Science 12 DOI: 10.3389/fpls.2021.629857.

Joscha, N., Becker, J.G., Abhijit, S.B., Reinhold-Hurek, A.E. (2024). Effects of Cowpea (*Vigna unguiculata*) Inoculation on Nodule Development and Rhizosphere Carbon and Nitrogen Content Under Simulated Drought. *Plant Soil,* 500:33-51. https://doi.org/10.1007/s11104-023-06051-1.

Kandil, A.E. and Halime, Ö.Ü (2023). Effect of rhizobium inoculation on yield and some quality properties of fresh cowpea. *Cogent Food & Agriculture*, 9: 2275410 https://doi.org/10.1080/23311932.2023.2275410.

Lal, Nitin S., Sandeep, Muhammad, A. A., Ravinder K., Awadhesh, K., Abhijit, D., Vijay, P., Brajesh, Singh, and Madan, P.S. (2022). From Source to Sink: Mechanistic Insight of Photoassimilates Synthesis and Partitioning Under High Temperature and Elevated [CO_2] *Plant Mol Biol,* 110(4-5):305-324 doi: 10.1007/s11103-022-01274-9.

Lal, R. (2009). Soil degradation is a reason for inadequate human nutrition. *Food Security, 1:* 45-57.

Lambot, C. (2002). Industrial potential of cowpea p. 367-375. In C. A. Fatokun, *et al*. (eds) Challenges and opportunities for enhancing sustainable cowpea production. Proc. of the World Cowpea Conference III held at the International Institute of Tropical Agriculture(IITA), Ibadan, Nigeria, 4-8 September 2000. IITA, Ibadan, Nigeria.

Lawrence, M., Kingsley, K.. Ayisi, G.H., Pascal, B. (2018). Screening Cowpea Genotypes for High Biological Nitrogen Fixation and Grain Yield under Drought Conditions. *Agronomy Journal,*110(5):1925-1935. https://doi.org/10.2134/agronj2017.01.0037.

Ma, Y., Liu, Y., Yang, P., Zhang, T., & Wu, Y. (2020). The synthesis mechanism of chlorogenic acid in leaves of Eucommia ulmoides Oliver. *Applied Ecology and Environmental Research*, 18(2), 2719–2725. https://doi.org/10.15666/aeer/1802_27192725

Makgato, M.J, Araya, H.T, du Plooy CP, Mokgehle, S.N., and Mudau, F.N, (2020). Effects of Rhizobium Inoculation on N_2 Fixation, Phytochemical Profiles and Rhizosphere Soil Microbes of Cancer Bush Lessertia frutescens (L.). Agronomy 10. doi: https://doi.org/10.3390/agronomy10111675

Malik, D. K., and Sindhu, S. S. (2011). Production of indole acetic acid by Pseudomonas sp.: Effect of coinoculation with Mesorhizobium sp. Cicer on nodulation and plant growth of chickpea (Cicer arietinum). *Physiology & Molecular*

Biology of Plants, 17(1):25–32.
Meng, Q., Jian, H. and Hao, J.J. (2016). Effects of Bacillus velezensis Strain BAC03 in Promoting Plant Growth. *Biological Control*, 98, 18-26. https://doi.org/10.1016/j.biocontrol.2016.03.010
Mohammed, Y., Abdelghani, N., Abdelwahed, M., Abdellatif, B. and Khalid, D. (2021). Application of Nitrogen Fertilizers and Inoculation. IOSR Journal of *Agriculture and Veterinary Science*, 10:32-38. https://doi.org/10.9790/2380-1004013238.
Nevhulaudzi, T., Sheku, A.K., Khayalethu, N. (2020). Interaction Effect of Bacillus Subtilis Co-Inoculation and Mine Water Irrigation on Cowpea's Growth, Physiology, and Nutritional Quality. *Scientific. Africa*, 9: e00541
NIMET (2023). *Agro-meteorological Bulletin. No. 9. Dekard 8, March (21-31) 2023. ISSN: 2315-9790.*
Nwofia, G.E., Ogbonna N.D., Agbo, C.U. and Mbah, E.U. (2018). Growth and Yield of Some Vegetable Cowpea Genotypes as Influenced by Planting Season. *Internal. J. Agric. For*. 5: 205-210.
Nwofia. G.E., Chinenye, R.O., Emmanuel, C.U. Mbah, E.U. (2015). Genotype by Planting Date Effects on Cowpea in Humid Fringes, Southeast Nigeria. *Plant Breed. Biotech*., 6(2):95-108 https://doi.org/10.9787/PBB.2018.6.2.95.
Nyaga, J.W. and Njeru, E.M. (2020) Potential of Native Rhizobia to Improve Cowpea Growth and Production in Semiarid Regions of Kenya. *Frontiers in Agronomy* 2. doi: https://doi.org/10.3389/fagro.2020.606293.
Okpara, D.A., and Oshilim, A.F. (2001). Response of Vegetable Cowpea (*Vigna unguiculata* (L.) Walp). Sub Species Plant *Breed. Biotech*., 6(2):95-108.
Olawale, R. O. and Bamaiyi, L. J. (2013). Management of cowpea insect pests. Scholars *Academic Journal of Biosciences*, 1 (5): 217-226.
Olayiwola, M.O.1., Soremi, P.A.S. and Okeleye, K.A. (2015). Evaluation of some cowpea (Vigna unguiculata L. [Walp]) genotypes for stability of performance over four years. Current Research in Agricultural Science 2(1):22-30 DOI: 10.18488/journal.68/2015.2.1/68.1.22.30
Olufajo, O.O., and Oladiran, A. (2018). Nodulation, Nitrogen Fixation and Productivity of Cowpea (*Vigna unguiculata*) Varieties as Influenced by Rhizobial Inoculation and Phosphorus Application on Farmers' Fields in Minna, Southern Guinea Savanna of Nigeria. *Production Agricultural Technology*(PAT), 14(2):131 – 139. ISSN: 0794 – 5213. www.patnsukjournal.net/currentissue.
Pablo, R., Barbara, C.M., Alain, M., Dalel, A., Noura, Z., Antoine K., and Christian, M. (2023). Mineralization and Speciation of Organic Phosphorus in a Sandy Soil Continuously Cropped and Phosphorus-fertilized for 28 years. *Soil Biology and Biochemistry,* 178: 108938
Perez E., Sulbaran M., Ball M. M., and Yarzabal, L.A. (2007) Isolation and characterization of mineral Phosphate-Solubilizing Bacteria Naturally Colonizing a Limonitic Crust in the South-Eastern Venezuelan Region, *Soil Biology and Biochemistry*, 39: 2905-2914.
Petu - Ibikunle, A.M., Buba, B. Shanni., Alawode, Yetunde., Goddey Okwukenye., and Tenebe. V.A. (2022). Determination of Cowpea's Productivity in Response to Some Agronomic Manipulation for Enhanced Adaptability and Introduction to Farming System of the Wet Savannah Ecology of Nigeria. (Unpublished).
Sabo, E. (2015) Studies on Cowpea Insect Pests Management Practices Among Cowpea (Vigna unguiculata L. Walp) Farmers in Mubi Zone, Nigeria. International *Journal of Agriculture Innovations and Research*, 3(6):1473.
Saini, H.S. and M.E. Westgate. (1999). Reproductive Development in Grain Crops During Drought. *Adv. Agron*., 68: 59-96.
Sato, S., Peet, M.M., and Thomas, J.F (2002). Determining Critical Pre and Post-Anthesis Periods and Physiological Processes in *Lycopersicon Esculentum* Mill. Exposed to Moderately Elevated Temperatures. *J. Exp. Bot*., 53: 1187-1195.
Schwartz, A.R., Ortiz, M., Maymon, C.W., Herbold, N.A., Fujishig, J.A., Vijanderan, W. Villella, K., Hanamoto, A., Diener, E.R., Sanders, D.A., DeMason, A.M. (2013). Bacillus Simplex—A Little Known Pgpb with Anti-Fungal Activity Alters Pea Legume Root Architecture and Nodule Morphology When Co-inoculated with Rhizobium Leguminosarum bv. Viciae.

Agronomy, 3:595-620.

Takeno, K. (2016). Stress-induced flowering: The third category of flowering response. *Journal of Experimental Botany*, 67(17):erw272. DOI: 10.1093/jxb/erw272.

Thalukanyo, N.S., Alfred, K., and Khayalethu, N. (2020). Interaction Effect of Bacillus Subtilis Co-Inoculation and Mine Water Irrigation on Cowpea's Growth, Physiology, and Nutritional Quality. Scientific African, e00541. https://doi.org/10.1016/j.sciaf.2020.e00541.

Tony. N., James, O. and Nixon, T. (2014) Cowpea Production Handbook ASHS Press, Alexandria, VA pp 45.

Tudi, M.D., Ruan, H., Wang, L., Lyu, J., Sadler, R., Connel. L.D., Chu, C., Phung, DT. (2021). Agriculture Development, Pesticide Application and Its Impact on the Environment, 18(3):1112. doi: 10.3390/ijerph18031112.

Vargas, L.K., Volpiano, C. G., Lisboa, B. B., Giongo, A., Beneduzi, A., & Passaglia, L.M.P. (2017). Potential of rhizobia as plant growth-promoting rhizobacteria. *Microbes for Legume Improvement*, 153–174.https://doi.org/10.1007/978-3-319-59174-2_7.

Vega, C.R.C., V.O. Sadras, F.H. Andrade and S.A. Uhart, 2000. Reproductive Allometry in Soybean, Maize and Sunflower. *Ann. Bot*., 85: 461-468

Verma, R., Annapragada, H., Katiyar, N., Shrutika, N., Das, K., & Murugesan, S. (2020). Rhizobium. *Beneficial Microbes in Agro-Ecology*, 37–54. https://doi.org/10.1016/B978-0-12-823414-3.00004-6.

Wallace, D.H., Baudoin, J.P., Beaver, J, Coyne, D.P., Halseth, D.E., and Masaya, P.N. (1991). Improving the efficiency of breeding for higher crop yield. Theor Appl. Genet. *86*, 27-40.

Wang, T.L., Wood, E.A., & Brewin, N.J. (1982). Growth Regulators, Rhizobium and Nodulation in Peas: Indole-3-acetic Acid from the Culture Medium of Nodulating and Non-nodulating Strains of R. leguminosarum. *Planta*, 155(4): 345–349. https://doi.org/10.1007/BF00429463.

Zahra, T., Mehran, R., Ali, A.T., Zahra, T., Mehran, R., Ali, A.T. (2019). Cowpea: Insect Children Pest Management In: Agricultural Research Updates. Volume 26 ISBN: 978-1-53614-930-2. Editors: Prathamesh Gorawala *et al*. © 2019 Nova Science Publishers, Inc.

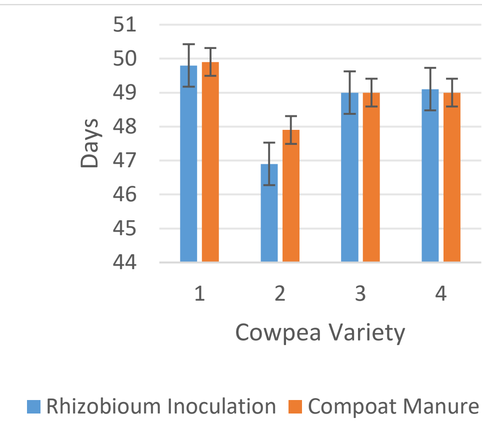

Plate 1. Effect of Variety X Nitrogen Source on Days taken to attaing 50% flowering in Cowpea

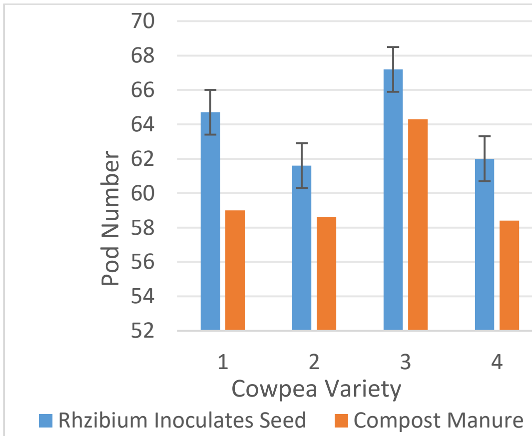

Plate2a. Effect of Variety X Nitrogen Source on Pod in of Cowpea at Location 1

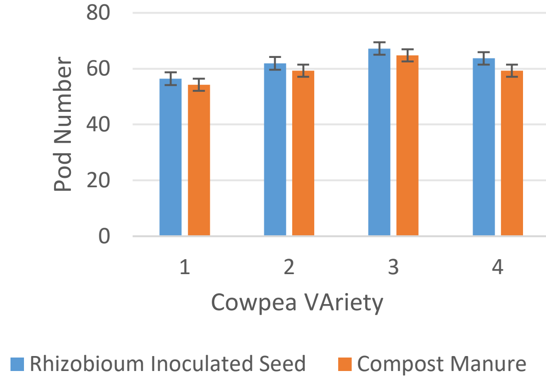

Figure 2b. Effect of VX Nitrogen Source on Pod Count of Cowpea At Location 2

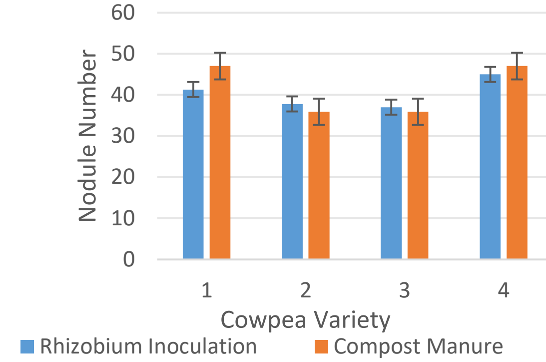

Figure 3b.Effect of Variety X Nitrogen Source on Pod Count of Cowpea at Location 2

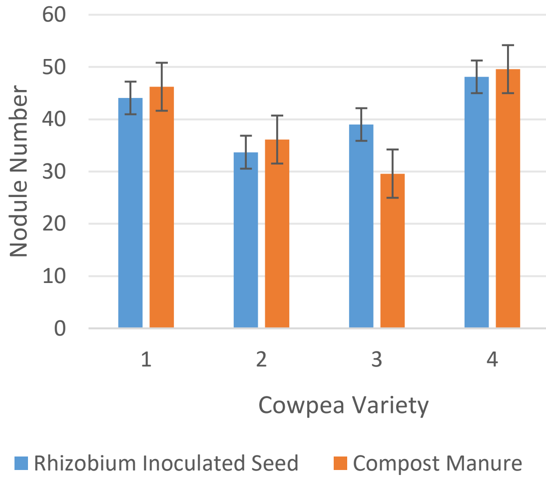

Figure 3a Effect of VarietyX Nitrogen Source on Cowpea at location2 Nodulation at Location 1

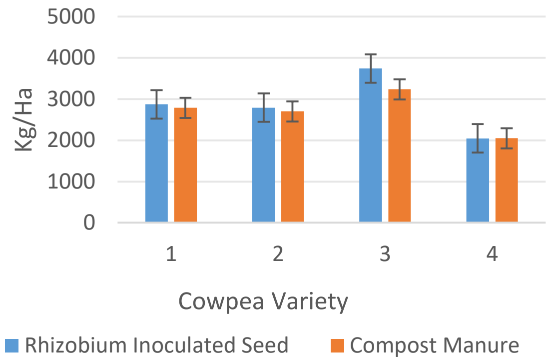

Figure 4a. Effect Variety X Source of Nitrogen on Cowpea DMY at Location1

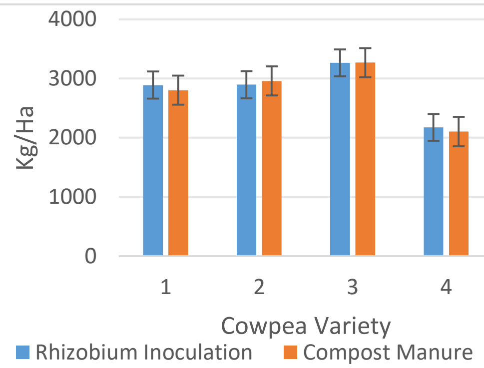

Figure 4B.Effect of VAriety X Source of Nitrogen on DMY of Cowpea at Location 2

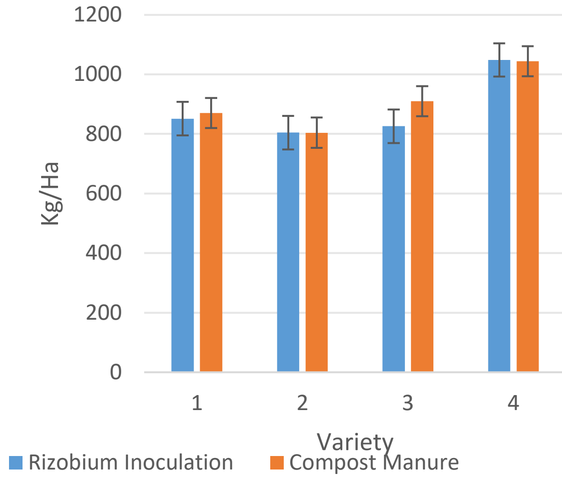

Figure 5a Effect of Variety Nitrogen Source on on Cowpea grain Yield At Location 1

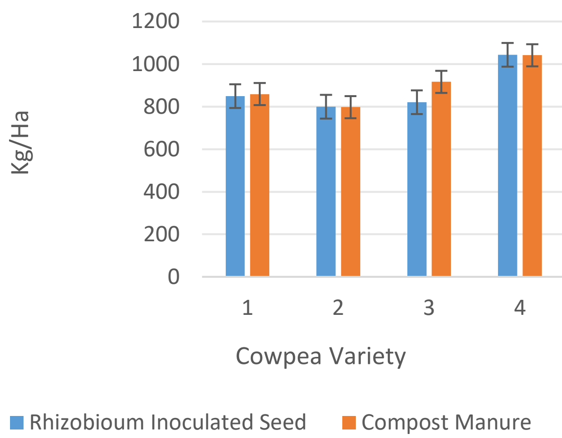

figure 5b,Effect of Variety X Nitrogen Source on grain yield of cowpea at Location 2

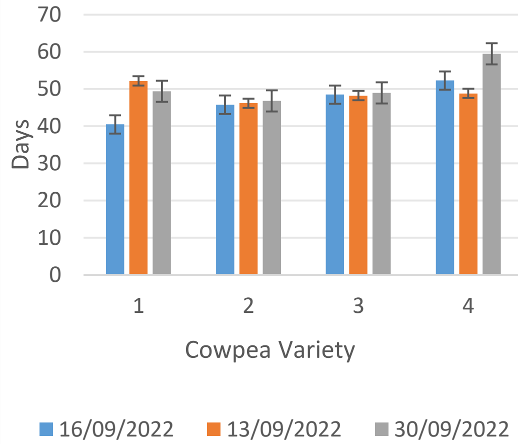

Figure 1a Effect of the Interaction of Varity and Sowing Date on Days to 50% Flowering of Cowpea at Location 1

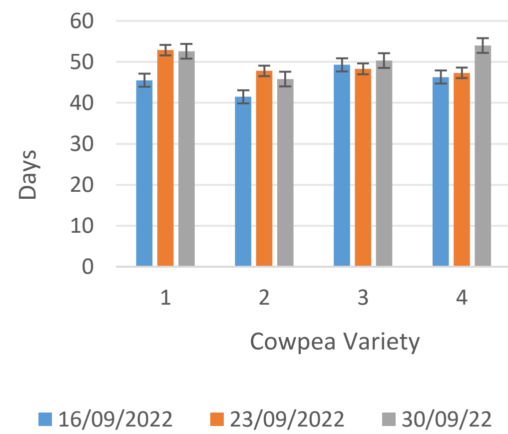

Figure 1b Effect of the Interaction of Variety and Sowing Date on Days to 50% flowering in Cowpea at Location 2

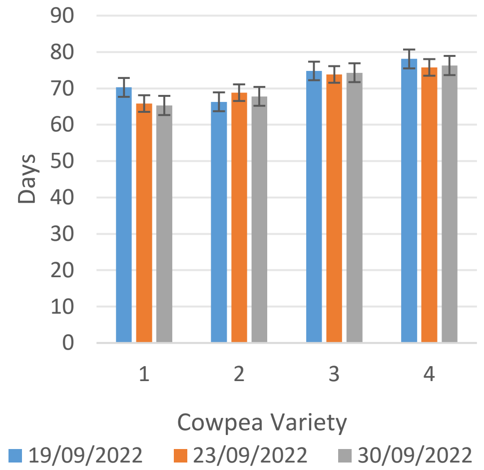

Figure 2a Effect the Interaction of Variety and Sowing Date on Days to 50% Pod Maturity of Cowpea on at Location1

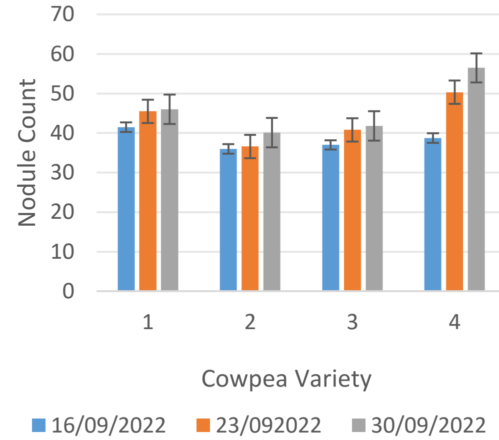

Figure 3a Effect of interaction Variety and Sowing Date Cowpea Nodulation at Location 1

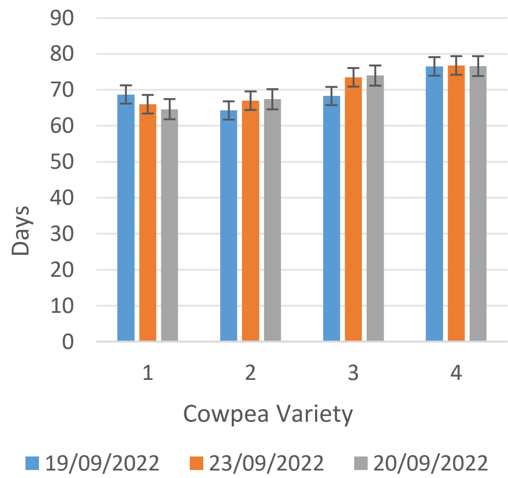

Figure 2b Effect of the Interaction of Variety and Sowing Date on Days to 50% Pod maturity at Location 1

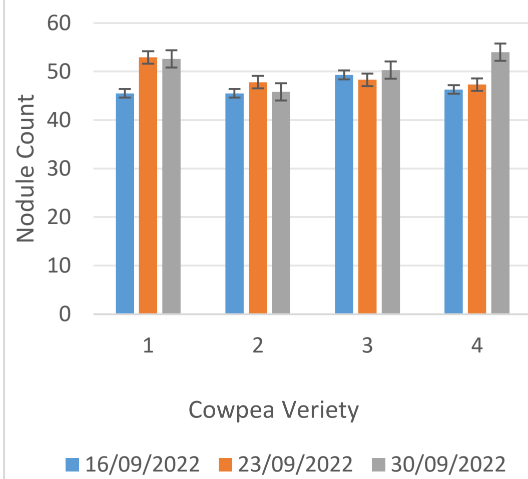

Figure 3b Effect of Interaction of Variety and Sowing Date on Cowpea Nodulation at Location 2

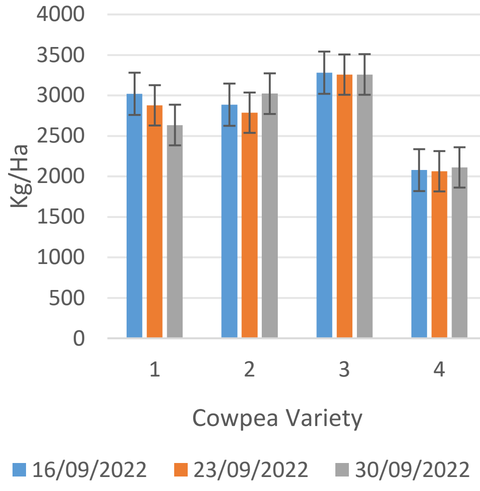

Figure 4a Effect of Interaction of Variety and Sowing Date on Dry Matter Yield of Cowpea at Location 1

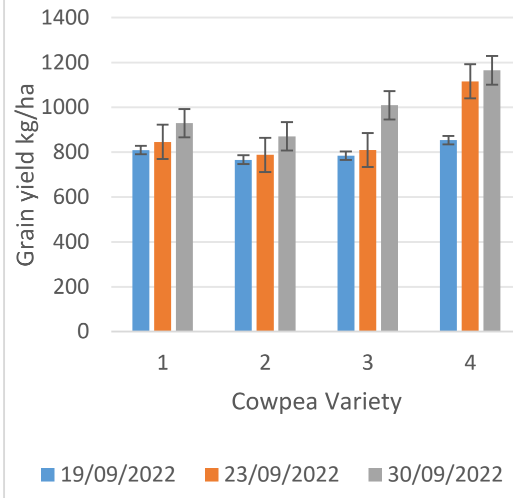

Table 5a Effect of the Interaction of Variety x Sowing Date on Cowpea Nodulation Location 1

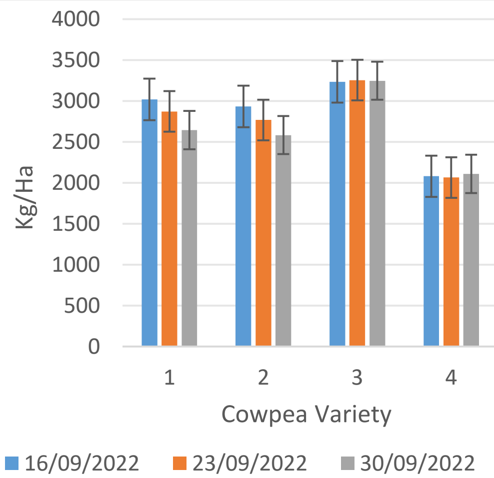

Figure 4b Effect of Interaction of Variety and Sowing Date of DMY of Cowpea at Location2

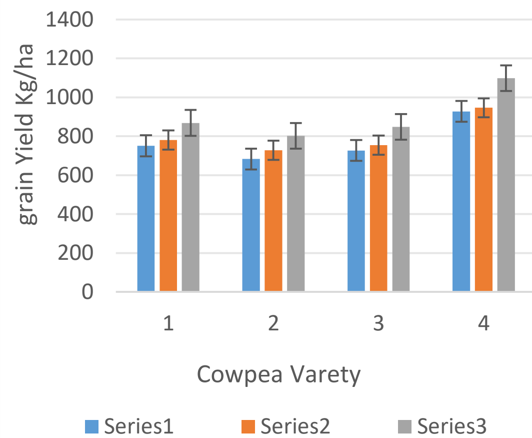

Figure 5b Effect of the Interaction Variety and Sowing Date on grain Yield of Cowpea at Location 2