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Research article

INFLUENCE OF MAIZE–COWPEA INTERCROPPING ON YIELD COMPONENTS AND PRODUCTIVITY OF IMPROVED COWPEA (VIGNA UNGUICULATA L. WALP) BREEDING LINES IN MAKURDI, NIGERIA

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ABSTRACT

Maize–cowpea intercropping is widely practiced by smallholder farmers in the Southern Guinea Savanna of Nigeria, yet the performance of cowpea breeding materials under interspecific competition can differ substantially. This study evaluated seven cowpea breeding lines under sole-crop and maize–cowpea relay-intercrop conditions at the College of Agronomy Teaching and Research Farm, University of Agriculture, Makurdi, during the 2024 cropping season. The experiment was a 2 × 7 factorial arranged in a randomized complete block design with three replications. The factors were cropping system (sole cowpea and maize–cowpea relay intercrop) and cowpea breeding line. Data were collected on phenological traits, yield components, cowpea grain yield and maize grain yield. Analysis of variance showed significant effects of cropping system and/or genotype for several cowpea traits, while the genotype × cropping-system interaction was significant for cowpea grain yield and dry fodder yield. Mean cowpea grain yield was 1,497.82 kg ha^{-1} under sole cropping and 946.38 kg ha^{-1} under intercropping. Across genotype × cropping-system combinations, UAM14-123-18-3 produced the highest grain yield under both sole (1,971.21 kg ha^{-1}) and intercrop (1,324.08 kg ha^{-1}) conditions. Percentage yield reduction varied from 23.1% in IT89KD-288 to 57.7% in UAM14-126-19-2, showing that yield reduction alone should not be used as a proxy for intercropping performance because low absolute yield can coexist with a small proportional reduction. The results identify UAM14-123-18-3 as the strongest overall performer in the tested environment and support further multi-location and on-farm evaluation of promising lines under maize-based intercropping.

KEYWORDS

Cowpea, maize–cowpea intercropping, breeding lines, grain yield, yield components, Southern Guinea Savanna.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is one of the most important grain legumes cultivated widely across sub-Saharan Africa and serves as a critical component of food security, nutrition, and rural livelihoods. The crop provides an affordable source of high-quality plant protein, essential vitamins, and minerals for millions of households, particularly in regions where animal protein is expensive or less accessible (Ikpe & Omede, 2025). In Nigeria, cowpea is valued not only for its protein-rich grains but also for its tender leaves, livestock fodder, and its contribution to soil fertility improvement through biological nitrogen fixation (Singh et al., 2003). Its adaptability to diverse environmental conditions, short growth duration, and ability to perform under low-input farming systems make it an indispensable crop in rain-fed agricultural environments. Nigeria remains one of the leading producers and consumers of cowpea globally, with the crop serving as a major component of traditional diets and a significant source of income for smallholder farmers. However, despite its importance, cowpea production is constrained by several biotic and abiotic factors, including insect pests, diseases, declining soil fertility, climate variability, and inefficient crop management practices. These challenges necessitate continuous efforts to develop and promote improved cowpea varieties with enhanced productivity and stability under prevailing farming conditions.

In the Southern Guinea Savanna agro-ecological zone of Nigeria, cowpea is rarely cultivated as a sole crop. Rather, it is predominantly grown in association with cereals, particularly maize, as part of traditional mixed cropping systems practiced by smallholder farmers. Maize–cowpea intercropping remains popular because it promotes efficient utilization of available land, reduces production risks associated with unpredictable climatic conditions, and provides multiple food products from the same piece of land. Furthermore, the complementary nature of cereal–legume associations contribute to improved soil fertility, better resource utilization, and suppression of weeds, thereby enhancing the sustainability of smallholder farming systems (Ofori & Stern, 1987). Intercropping, which involves the cultivation of two or more crops simultaneously on the same piece of land, is a common agricultural practice among small-scale farmers in Nigeria due to increasing population pressure, limited availability of arable land, and the need to maximize productivity from available resources (Iwuagwu, 2020). The system often involves combining tall and short crops, particularly cereals and legumes, where differences in plant architecture and resource requirements can create opportunities for complementary resource use (Undie et al., 2012). Intercropping has been recognized as an important strategy for sustainable agricultural intensification because it improves land-use efficiency, enhances soil health, promotes biodiversity, and contributes to long-term ecosystem stability (Deborah et al., 2022).

Globally, intercropping systems contribute significantly to food production and have been estimated to provide as much as 15–20% of the world's food supply (Altieri, 1999, as cited in Bedoussac et al., 2018). Recent studies have described intercropping as a potential pathway toward a "new green revolution" because of its capacity to increase productivity per unit area through effective exploitation of complementary interactions among different crop species (Xu et al., 2020). The recent global meta-analysis by Li et al. (2023), for example, evaluates intercropping performance using grain, calorie and protein yields across field experiments but does not establish that intercropping currently supplies 15–20% of global food. Despite the numerous advantages associated with maize–cowpea intercropping, the system is characterized by competition between component crops for essential growth resources, including solar radiation, water, and nutrients. In maize–cowpea mixtures, maize often exhibits greater competitive ability because of its taller growth habit, rapid early development, and extensive canopy formation. Consequently, cowpea plants may experience shading and reduced access to critical resources, which can negatively affect vegetative growth, flowering time, pod development, and final grain yield. However, the degree of yield reduction experienced by cowpea under intercropping conditions varies considerably among genotypes due to differences in growth habit, maturity period, phenological plasticity, and competitive ability (Willey, 1979).

Historically, cowpea breeding and evaluation programmes in Nigeria have largely focused on performance under sole cropping conditions. Although this approach has contributed significantly to the development and release of improved high-yielding varieties, it does not adequately represent the production realities of most smallholder farmers who rely heavily on intercropping systems. Consequently, some improved cowpea varieties that demonstrate excellent performance under research station conditions may fail to maintain similar productivity when grown under farmers' mixed cropping environments. This disparity between breeding environments and farmers' production practices underscores the importance of evaluating cowpea genotypes under realistic intercropping conditions. Understanding the response of cowpea genotypes to maize-based intercropping systems is therefore essential for identifying varieties with superior adaptation, competitive ability, and yield stability. Evaluation of phenological traits, yield components, and grain yield under intercropping conditions provides valuable information for breeding programmes, crop management recommendations, and extension strategies aimed at improving productivity among smallholder farmers.

Furthermore, identifying cowpea genotypes capable of maintaining desirable growth and yield performance under interspecific competition will contribute to the development of resilient cropping systems capable of addressing challenges associated with climate variability, declining soil fertility, and increasing demand for food production. Such research is particularly important in the Southern Guinea Savanna zone of Nigeria, where maize–cowpea intercropping remains a dominant agricultural practice (Isaac & Ikpe, 2024). Therefore, this study was conducted to evaluate the influence of maize–cowpea intercropping on the phenological development, yield components, and grain yield of selected improved cowpea breeding lines in Makurdi, Nigeria, with particular emphasis on identifying genotypes that exhibit tolerance to intercropping-induced stress and possess desirable characteristics for sustainable production systems.

MATERIALS AND METHODS

Study Area

The experiment was conducted during the 2024 cropping season at the College of Agronomy Teaching and Research Farm of the University of Agriculture, Makurdi, Benue State, Nigeria. The site is located within the Southern Guinea Savanna agro-ecological zone at approximately 7.76°N and 8.62°E, with an elevation of about 103 m. The area experiences a unimodal rainfall pattern, with annual rainfall ranging from 1,100 to 1,300 mm. The rainy season typically begins in April and ends in October. Mean daily temperatures range from 26 to 32 °C, and the soils are predominantly sandy loam with moderate fertility.

Experimental Materials

The experimental materials comprised seven cowpea (*Vigna unguiculata* (L.) Walp.) breeding lines, namely UAM091051-1, IT89KD-288, UAM14-122-17-7, UAM14-127-20-1-1, UAM14-123-18-3, UAM14-126-19-2, and UAM14-130-20-4. The cowpea materials and the maize variety 99EVDT used as the companion crop were obtained from the Molecular Biology Laboratory, University of Agriculture, Makurdi, Benue State, Nigeria.

Experimental Design and Crop Management

The experiment comprised two cropping systems (sole cowpea and maize–cowpea relay intercropping) and seven cowpea breeding lines in a 2 × 7 factorial arrangements. Treatments were laid out in a randomized complete block design with three replications, giving 42 experimental units. Each plot measured 3 m × 4 m (12 m^2) and consisted of four ridges spaced 0.75 m apart. A 1.5-m alley was maintained to facilitate field operations. The cropping systems were sole cowpea and maize–cowpea relay intercropping, while the seven cowpea breeding lines were UAM091051-1, IT89KD-288, UAM14-122-17-7, UAM14-127-20-1-1, UAM14-123-18-3, UAM14-126-19-2, and UAM14-130-20-4. The treatments were arranged in a Randomized Complete Block Design (RCBD) with three replications. Each cowpea breeding line was randomly assigned to each cropping system within each replication, resulting in 42 experimental units (2 cropping systems × 7 cowpea breeding lines × 3 replications). Each experimental plot measured 3 m × 4 m (12 m^2) and consisted of four ridges spaced 0.75 m apart. A 1.5-m alley was maintained between appropriate plots to facilitate movement and field operations.

Maize variety 99EVDT was planted in the designated intercrop plots on 8 July 2024 at 75 cm inter-row spacing and 50 cm intra-row spacing. Three maize seeds were initially sown per hill and subsequently thinned to two plants per hill. Maize was planted at the recommended planting depth for the variety. Cowpea was planted as a sole crop and introduced into the standing maize as a relay intercrop on 11 September 2024, approximately nine weeks after maize establishment. Cowpea was planted at 25 cm intra-row spacing, with three seeds per hill and subsequently thinned to two plants per hill at two weeks after planting. The same cowpea planting geometry was used in both the sole-crop and relay-intercrop treatments.

Fertilizer application was carried out according to the nutrient requirements of the component crops. For maize, NPK 15:15:15 fertilizer was applied at 400 kg ha^{-1} 10 days after planting, providing a nutrient equivalent of 60 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1}. Following the establishment of cowpea in the relay-intercropping treatment, urea (46% N) was applied as a top dressing at a rate equivalent to 60 kg N ha^{-1}. This corresponds to approximately 130.4 kg urea ha^{-1} and resulted in a cumulative nutrient application of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} to the maize component.

For cowpea, single superphosphate (SSP) was applied basally at 40 kg ha^{-1}. The actual nutrient contribution of the SSP was dependent on its formulation. Where SSP contained 18% P_2O_5, the 40 kg ha^{-1} application supplied approximately 7.2 kg P_2O_5 ha^{-1}. The SSP was applied as a separate phosphorus source to support cowpea establishment, root development and nodulation and was not included in the stated 120:60:60 N:P_2O_5:K_2O nutrient rate applied to maize.

Fertilizer applications were made uniformly across the relevant experimental units according to the treatment protocol. No additional nitrogen fertilizer was applied specifically to the cowpea component beyond the nitrogen supplied incidentally through the common field fertilizer regime, thereby avoiding excessive nitrogen application that could interfere with biological nitrogen fixation. Weed control was carried out manually throughout the experimental period. Maize plots were manually weeded at 2 and 5 weeks after sowing (WAS), while cowpea plots were weeded at 3 and 6 weeks after planting (WAP). The prescribed weed-management operations were applied uniformly to the relevant treatments to minimize weed competition and maintain field sanitation. All other agronomic practices were applied uniformly across the experimental units. Thus, differences in growth, yield and other measured characteristics were attributed primarily to the effects of the cropping systems and cowpea breeding lines rather than differences in field management.

Data Collection

Measurements were taken from the two middle/net rows or net plots and averaged. The traits recorded included days to first flowering, days to 50% flowering, canopy height at 32 days after planting, days to 95% pod maturity, number of branches per plant, number of pods per plant, number of seeds per pod, number of peduncles per plant, total pod weight, 100-seed weight, total grain weight, moisture content and dry fodder weight. Maize grain weight was also recorded.

Statistical Analysis

Data obtained from the experiment were subjected to analysis of variance (ANOVA) using Minitab Statistical Software, Version 17. The experiment was analyzed as a 2 × 7 factorial arrangement in a Randomized Complete Block Design (RCBD) with three replications. The statistical model included the effects of replication (block), cropping system, cowpea breeding line, and the cropping system × cowpea breeding line interaction. The model was specified as:

$Y_{ijk} = \mu + R_i + C_j + G_k + (C \times G)_{jk} + \varepsilon_{ijk}$

Where:

- Y_{ijk} = observed value of the response variable for the *i*th replication, *j*th cropping system, and *k*th cowpea breeding line;
- μ = overall experimental mean;
- R_i = effect of the *i*th replication (block);
- C_j = effect of the *j*th cropping system;
- G_k = effect of the *k*th cowpea breeding line;
- $(C \times G)_{jk}$ = interaction effect between cropping system and cowpea breeding line;

- ε_{ijk} = random experimental error.
- i =1,2,3 replications;
- j =1,2 cropping systems (sole cowpea and maize–cowpea relay intercrop); and
- k =1, 2…,7 cowpea breeding lines.

The ANOVA tested the significance of the main effects of cropping system and cowpea breeding line, as well as their interaction. The assumptions of the analysis, including normality of residuals, independence of observations, and homogeneity of variance, were assessed using residual diagnostics. Statistical significance was declared at $P \leq 0.05$.

Where a significant F-test was obtained, treatment means were compared using Least Significant Difference (LSD) test at the 5% probability level. Mean separation was performed only for effects that were statistically significant in the corresponding ANOVA. The results were presented as means with appropriate measures of variability, and the ANOVA results were reported using F-statistics, degrees of freedom, and associated P-values.

The percentage reduction in grain yield associated with intercropping relative to sole cropping was calculated as:

Where:

- GYR = percentage grain-yield reduction due to intercropping;
- Y_s = grain yield under sole cowpea cropping;

Y_i = grain yield under maize–cowpea intercropping.

RESULTS AND DISCUSSION

Phenological Response of Cowpea to Maize Intercropping

Maize–cowpea intercropping had a clear effect on cowpea phenological development. Cowpea plants grown under intercropping conditions flowered and matured later than those grown as sole crops.

Table 1. Phenological Response of Cowpea to Maize Intercropping (Mean Delay in Days)

SN	Trait	Sole cropping (days)	Intercropping (days)	Mean delay (days)
A	Days to first flowering	46.57	48.19	+1.62
B	Days to 50% flowering	49.33	51.19	+1.86
C	Days to maturity	71.81	73.90	+2.09

Source: Field work, 2024

The observed delay in flowering and maturity of cowpea under maize–cowpea intercropping conditions is most likely associated with the shading effects imposed by the maize canopy, which reduced the quantity and quality of solar radiation available to cowpea plants during critical stages of vegetative and reproductive development. Since light availability plays a fundamental role in photosynthesis, assimilate production, and regulation of developmental processes, reduced light interception may have limited photosynthetic efficiency, thereby slowed plant growth and delayed the transition from vegetative to reproductive phases.

In addition to light competition, the delayed phenological development may also be attributed to increased competition between maize and cowpea for other essential growth resources, including soil moisture and nutrients. The taller and faster-growing maize plants often establish dominance within the intercrop system, creating a competitive environment that restricts the growth and development of the associated cowpea plants. Under such conditions, cowpea may experience physiological stress, leading to delayed flowering, prolonged maturity period, and possible reductions in yield formation.

The extent of delay in flowering and maturity may also depend on the genetic characteristics of the cowpea genotypes, including growth habit, maturity duration, canopy architecture, and ability to tolerate low-light environments. Genotypes with greater phenological plasticity and improved resource-use efficiency may adjust better to intercropping stress and maintain relatively stable developmental patterns compared with susceptible genotypes.

Similar delays in phenological development under cereal–legume intercropping systems have been reported by Willey (1979), who attributed such responses to increased competition for light, nutrients, and water between component crops. These findings suggest that interspecific competition in maize–cowpea systems can significantly influence the timing of key developmental stages, emphasizing the importance of evaluating cowpea genotypes under actual intercropping environments rather than relying solely on sole-crop performance. Understanding these phenological responses is essential for identifying cowpea varieties that can effectively adapt to mixed cropping systems and sustain productivity under smallholder farming conditions.

The analysis of variance (ANOVA) showed significant genotype effects for days to first flowering, days to 50% flowering, canopy height, number of branches, number of seeds per pod, number of peduncles, total pod weight, total grain weight and dry fodder weight. Cropping system significantly affected days to first flowering, days to 50% flowering, number of branches, number of pods, number of peduncles, total pod weight, total grain weight and dry fodder weight. The genotype × cropping-system interaction was significant for cowpea total grain weight and dry fodder weight, while it was not significant for the other listed traits.

Table 2. Analysis of variance (ANOVA) showing genotype effects for days to first flowering, days to 50% flowering, canopy height.

Source	df	DFF	D50F	Canopy height	D95PM	Branches/plant
Replication	2	—	—	—	—	—
Genotype (G)	6	32.50**	133.63**	14.66*	11.15 ns	4.89**
Cropping system (C)	1	40.02**	44.02**	1.33 ns	22.88 ns	10.30**
G × C	6	3.57 ns	0.74 ns	10.85 ns	8.10 ns	0.63 ns
CV (%)	—	7.36	10.38	9.24	4.09	40.13

Table 3. Analysis of variance (ANOVA) showing genotype effects for number of seeds per pod, number of peduncles, total pod weight, total grain weight and dry fodder weight

Source	df	Pods/plant	Seeds/pod	Peduncles/plant	Pod weight	Cowpea grain yield	Maize grain yield	Dry fodder
Genotype (G)	6	105.52 ns	3.80**	253.07**	2,024,723**	782,765**	95,583 ns	737,959**
Cropping system (C)	1	524.35**	0.59 ns	934.37**	10,935,168**	3,192,918**	0 ns	13,130,165**
G × C	6	56.88 ns	0.29 ns	72.96 ns	271,191 ns	131,391**	161,791 ns	527,465*
CV (%)	—	35.52	9.10	40.79	33.49	38.92	31.74	53.65

Note: ** = highly significant; * = significant; ns = not significant.

Effect of Intercropping on Cowpea Yield Components

Intercropping significantly affected key cowpea yield components, with reductions observed across all measured traits (Table 4). Among the yield components, pods per plant were most affected by maize intercropping.

Table 4. Effect of Intercropping on Cowpea Yield Components

Cropping system	DFF	D50F	Height	D95PM	Branches	Pods	Seeds/pod	Peduncles	Pod wt.	Cowpea grain	Maize grain	Dry fodder
Intercrop	40.47ᵃ	46.33ᵃ	29.47ᵃ	79.28ᵃ	2.69ᵇ	21.85ᵇ	11.56ᵃ	19.75ᵇ	1961.22ᵇ	946.38ᵇ	1604.63ᵃ	892.86ᵇ
Sole	38.52ᵇ	44.28ᵇ	29.83ᵃ	77.80ᵃ	3.66ᵃ	28.92ᵃ	11.80ᵃ	29.19ᵃ	2981.73ᵃ	1497.82ᵃ	1604.63ᵃ	2011.11ᵃ

Means followed by different letters within a column differ significantly

Intercropping delayed first flowering and 50% flowering and reduced the number of branches, pods per plant, peduncles per plant, pod weight, cowpea grain yield and dry fodder yield. Canopy height, days to 95% pod maturity, seeds per pod and maize grain yield did not differ significantly between cropping systems.

Table 5. Percentage Reduction in Cowpea Yield Components Due to Maize Intercropping

SN	Yield component	Sole cropping	Intercropping	Reduction (%)
A	Pods per plant	13.21	11.07	16.2
B	Seeds per pod	11.34	10.92	3.7
C	100-seed weight (g)	17.03	16.42	3.6

Source: Field work, 2025

Table 5 presents the percentage reduction in selected cowpea yield components resulting from maize intercropping. The results indicate that maize–cowpea intercropping had a greater negative influence on the number of pods produced per plant compared with other yield components. Pods per plant recorded the highest reduction (16.2%), declining from 13.21 under sole cropping to 11.07 under intercropping conditions. In contrast, seeds per pod and 100-seed weight showed relatively smaller reductions of 3.7% and 3.6%, respectively.

The greater reduction observed in pods per plant suggests that intercropping stress primarily affected reproductive initiation and pod establishment rather than seed development and grain filling processes. The formation of flowers and pods represents a critical stage in cowpea production, and any limitation in photosynthetic activity or assimilate availability during this period can result in flower abortion, poor pod setting, and reduced pod number.

The reduction in pod formation under intercropping conditions may be attributed largely to competition for light caused by the maize canopy. Due to its taller growth habit and more aggressive early development, maize intercepts a substantial proportion of incoming solar radiation, thereby reducing light penetration to the cowpea canopy. Insufficient light availability during the reproductive phase can decrease photosynthetic capacity, restrict carbohydrate production, and reduce the supply of assimilates required for successful flower retention and pod development (Boko & Iheanacho, 2021).

Furthermore, competition for soil moisture and nutrients between maize and cowpea may have contributed to reduced reproductive performance. Although cowpea has the ability to fix atmospheric nitrogen, it still requires adequate availability of water and other essential nutrients, particularly during flowering and pod filling stages. Under intercropping conditions, resource limitations may increase physiological stress, leading to reduced reproductive success.

The relatively lower reductions observed in seeds per pod and 100-seed weight indicate that once pods were successfully established, the effect of intercropping on seed development and grain filling was comparatively limited. This suggests that maize competition exerted a stronger influence during the early reproductive stages of cowpea than during the final stages of seed maturation. Similar findings have been reported in cowpea and other leguminous crops grown under cereal–legume intercropping systems, where competition effects are often expressed more strongly through reductions in reproductive structures rather than individual seed size (Willey, 1979).

The results further highlight the importance of selecting cowpea genotypes with improved ability to maintain reproductive development under competitive environments. Genotypes capable of sustaining higher pod production under maize intercropping may possess desirable traits such as efficient light utilization, greater phenological plasticity, and improved tolerance to resource competition. Such characteristics are essential for developing cowpea varieties suitable for the prevailing mixed cropping systems practiced by smallholder farmers in Nigeria.

Grain Yield Reduction under Maize–Cowpea Intercropping

Cowpea grain yield was consistently higher under sole cropping than under maize intercropping. However, the extent of yield reduction differed among breeding lines, reflecting genetic variability in tolerance to intercropping stress (Table 3).

Cowpea grain yield was consistently higher under sole cropping than under maize intercropping. However, the extent of yield reduction differed among breeding lines, reflecting genetic variability in tolerance to intercropping stress (Table 6).

Table 6. Genotype × cropping-system interaction for grain yield

Breeding line	Sole grain yield (kg ha^{-1})	Intercrop grain yield (kg ha^{-1})	Reduction (%)
UAM14-123-18-3	1,971.21	1,324.08	32.8
UAM14-122-17-7	1,542.32	1,164.00	24.5
UAM14-127-20-1-1	1,812.33	1,058.14	41.6
UAM14-130-20-4	1,476.91	888.50	39.8
UAM09-1051-1	1,299.89	888.50	31.6
UAM14-126-19-2	1,814.00	767.00	57.7
IT89KD-288	568.11	436.72	23.1

UAM14-123-18-3 recorded the highest grain yield in both systems (1,971.21 kg ha^{-1} sole and 1,324.08 kg ha^{-1} intercrop). IT89KD-288 had the lowest absolute grain yield under both systems, but its proportional reduction was also the smallest (23.1%). UAM14-126-19-2 showed the largest proportional reduction (57.7%). This demonstrates why a genotype should not be labelled 'tolerant' solely from percentage reduction without considering absolute intercrop productivity.

DISCUSSION

The observed delay in flowering under intercropping is consistent with the competitive environment created by the taller maize component. In the present experiment, cowpea first flowering increased from 38.52 days in sole cropping to 40.47 days under intercropping, while days to 50% flowering increased from 44.28 to 46.33 days. These differences were significant in the supplied ANOVA. Reduced radiation interception by cowpea beneath a maize canopy provides a plausible explanation, although radiation was not measured directly in this experiment. Similar competition effects have been discussed for cereal–legume mixtures (Willey, 1979; Ofori & Stern, 1987). Intercropping also reduced several reproductive traits. Pods per plant declined from 28.92 under sole cropping to 21.85 under intercropping, while branches and peduncles per plant were also lower in the intercrop. In contrast, seeds per pod did not differ significantly between cropping systems. The pattern suggests that competition affected the formation of reproductive structures more strongly than the number of seeds retained within established pods. However, physiological mechanisms such as photosynthetic rate, radiation interception or assimilate partitioning were not measured and should therefore be regarded as plausible explanations rather than demonstrated mechanisms.

The most important production response was the reduction in cowpea grain yield from 1,497.82 kg ha^{-1} in sole cropping to 946.38 kg ha^{-1} in intercropping. This represents an overall reduction of approximately 36.8% at the cropping-system mean level. The genotype × cropping-system interaction for cowpea grain yield was significant in the supplied ANOVA, confirming that the magnitude of response depended on genotype. This interaction provides stronger evidence for differential performance than the small reduction range reported in the earlier manuscript version. UAM14-123-18-3 was the strongest overall performer, yielding 1,324.08 kg ha^{-1} under intercropping and 1,971.21 kg ha^{-1} in sole cropping. UAM14-122-17-7 also maintained relatively high intercrop yield (1,164.00 kg ha^{-1}). UAM14-127-20-1-1 produced 1,058.14 kg ha^{-1} under intercropping. These materials therefore combine comparatively high absolute productivity with acceptable performance under the competitive environment. In contrast, IT89KD-288 produced only 436.72 kg ha^{-1} under intercropping despite having the smallest proportional reduction. Its case illustrates the limitation of using percentage yield reduction alone as a breeding criterion.

The significant genotype × cropping-system interaction for dry fodder yield further indicates that genotype responses were not uniform across cropping systems. However, the present study did not directly measure plant architecture, light interception, root traits, water use, nutrient uptake or physiological efficiency. Consequently, claims that particular lines possess superior shade tolerance, resource-use efficiency or specific adaptive mechanisms should be treated as hypotheses for subsequent studies rather than conclusions established by the present experiment. The findings are consistent with the broader literature in the supplied thesis source, which emphasizes genetic variability among cowpea materials and the importance of evaluating genotypes under the environments in which they will be cultivated. The present results also agree with the rationale for evaluating cowpea specifically under maize-based intercropping in the Southern Guinea Savanna, where mixed cropping is a common farmer practice.

CONCLUSION

The 2024 field experiment demonstrated that maize–cowpea relay intercropping significantly altered several cowpea phenological and yield-related traits. Relative to sole cropping, intercropping delayed flowering and reduced branches, pods per plant, peduncles per plant, pod weight, cowpea grain yield and dry fodder yield. The genotype × cropping-system interaction for grain yield was significant, demonstrating that cowpea breeding lines did not respond uniformly to intercropping. UAM14-123-18-3 was the highest-yielding line under both sole and intercropped conditions and therefore represents the strongest candidate for further evaluation in maize-based production systems. UAM14-122-17-7 and UAM14-127-20-1-1 also showed comparatively good intercrop grain yield. Because absolute intercrop yield and proportional yield reduction produced different rankings for some lines, both measures should be considered when selecting materials for intercropping.

RECOMMENDATIONS

1. Cowpea breeding programs should routinely evaluate genotypes under maize-based intercropping systems to ensure relevance to farmers' production environments.
2. Intercropping-tolerant breeding lines identified in this study should be advanced for multi-location and on-farm trials.
3. Farmers practicing maize–cowpea intercropping in the Southern Guinea Savanna should adopt cowpea varieties with proven tolerance to interspecific competition to improve productivity and system sustainability.
4. Advance UAM14-123-18-3, UAM14-122-17-7 and UAM14-127-20-1-1 to multi-location and on-farm trials under maize-based intercropping before any recommendation for broad farmer adoption.
5. Evaluate the promising lines across contrasting maize densities, row arrangements and relay-planting dates to determine management combinations that reduce competition and improve cowpea productivity.
6. Use both absolute intercrop grain yield and proportional yield reduction when screening breeding materials; percentage reduction alone can favour low-yielding genotypes.

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