ID: 620

Yield Performance and Genetic Gain Potential of Indigenous Leafy Vegetables Under Different Harvest Frequencies

Yusuf Abdulkareem[1], Yusuf Abdulkareem[1]
[1]Department of Crop Production, Faculty of Agriculture, Kwara State University, Malete, Nigeria.

Abstract

Indigenous leafy vegetables such as African spinach (*Amaranthus hybridus*), Lagos spinach (*Celosia argentea*), and Jute mallow (*Corchorus olitorius*) are widely cultivated and consumed in tropical and subtropical regions due to their high nutritional value and contribution to food security. These vegetables provide essential vitamins, minerals, dietary fibre, and plant-based protein that support healthy diets and improve nutritional status. However, their productivity is often affected by poor agronomic practices, particularly inappropriate harvesting frequency and cutting cycles, which influence vegetative growth and cumulative leaf yield. This study evaluated the response of open-pollinated varieties of African spinach, Lagos spinach, and Jute mallow to different harvesting regimes in order to determine the most suitable harvest interval for improved cumulative leaf yield under the Southern Guinea Savannah agro-ecological conditions of Nigeria. A screen house experiment was conducted using a Completely Randomized Design with three replications. Six vegetable varieties were subjected to three harvesting regimes, namely weekly harvesting, fortnightly harvesting, and harvesting at maturity. Data were collected on plant height, stem girth, number of leaves, and cumulative leaf yield and analysed using analysis of variance. Results revealed significant ($p < 0.05$) genotypic variability among the evaluated vegetables across harvesting regimes. African spinach (Tete – Local) recorded the highest cumulative leaf yield, followed by Lagos spinach (Shoko – Local), whereas Jute mallow varieties produced comparatively lower yields. The fortnightly harvesting regime produced the highest cumulative yield and exhibited high heritability (0.70) with genetic advance of 25%. Fortnightly harvesting is therefore recommended for improving cumulative leaf yield in indigenous leafy vegetables.

Key Words: *Indigenous leafy vegetables, Harvesting frequency, Cumulative leaf yield, Genetic variability, Southern Guinea Savannah*

Introduction

Indigenous leafy vegetables such as African spinach (*Amaranthus hybridus*), Lagos spinach (*Celosia argentea*), and Jute mallow (*Corchorus olitorius*) play a vital role in enhancing food and nutritional security across tropical and subtropical regions. These vegetables are widely grown and consumed in West Africa because they are rich in essential nutrients, including vitamins, minerals, dietary fibre, and plant-based protein, all of which contribute to improved health and a more diversified diet (Schippers, 2000; Grubben and Denton, 2004).

African spinach (*Amaranthus hybridus*), a member of the Amaranthaceae family, is among the most commonly cultivated leafy vegetables in tropical Africa. It is valued for its fast growth, high biomass production, and ability to adapt to a wide range of environmental conditions (Mnkeni et al., 2007). In the same way, Lagos spinach (*Celosia argentea*), which also belongs to the Amaranthaceae family, is widely cultivated for its edible leaves and tender shoots that are commonly used in soups and stews (Denton, 2004). Jute mallow (*Corchorus olitorius*), a member of the Malvaceae family, is similarly cultivated for its mucilaginous leaves, which are rich in micronutrients and essential minerals, making it an important part of the diet for both rural and urban populations (Opabode and Adebooye, 2005; Nyadanu et al., 2017).

Despite their nutritional value, the productivity of these indigenous leafy vegetables is often limited by poor management practices, particularly inappropriate harvesting frequency and cutting cycles. Leaf harvesting directly affects vegetative growth by reducing the photosynthetic surface area needed for carbohydrate production and biomass accumulation. Frequent defoliation can slow down the regeneration of new leaves, while delayed harvesting may result in senescence and a shift of assimilates towards reproductive growth rather than vegetative development (Kiozya et al., 2001; Masumba, 2004).

Harvesting regime and cutting cycle therefore represent important management practices that influence leaf yield, regrowth ability, and yield productivity in leafy vegetables. Harvesting at appropriate intervals gives the plant enough time to recover through assimilate redistribution and meristematic regrowth following defoliation, which ultimately improves cumulative leaf production (Barg et al., 2008; Gil et al., 2012). On the other hand, excessive harvesting frequency can reduce leaf size and delay the formation of new leaves, thereby limiting overall biomass production (Dupriez and De Leener, 1989).

Open-pollinated varieties (OPVs) of indigenous vegetables are widely cultivated by farmers because of their adaptability, genetic diversity, and ability to maintain stable yields under varying environmental conditions (Glaszmann et al., 2010). However, there is limited information on how OPVs of African spinach, Lagos spinach, and Jute mallow respond to different harvesting regimes and cutting cycles under the Southern Guinea Savannah agro-ecological conditions of Nigeria.

This study was therefore conducted to evaluate the response of open-pollinated varieties of African spinach (*Amaranthus hybridus*), Lagos spinach (*Celosia argentea*), and Jute mallow (*Corchorus olitorius*) to different harvesting regimes and cutting cycles in order to identify the optimal harvest frequency for improved cumulative leaf yield.

Materials And Methods

Experimental Site

The experiment was conducted in the Screen House of Kwara State University (KWASU), Malete, located at latitude 08°43′N and longitude 4°28′E, at an altitude of approximately 316 m above sea level within the Southern Guinea Savannah agro-ecological zone of Nigeria. The study area is characterized by a tropical climate with an average annual rainfall of about 1500 mm, mean maximum temperature of approximately 38°C, relative humidity of about 75%, and an average daily photoperiod of 7.1 hours. The experiment was carried out between March and June 2022.

Planting Materials

Planting materials consisted of open-pollinated varieties of three indigenous leafy vegetables, namely African spinach (*Amaranthus hybridus*), Lagos spinach (*Celosia argentea*), and Jute mallow (*Corchorus olitorius*). The African spinach varieties used were Tete Agric (T1) and Tete Local (T2), while the Lagos spinach varieties included Shoko Local (S1) and Shoko Hausa (S2). The Jute mallow varieties used were Ewedu Local (E1) and Ewedu Hausa (E2). Seeds of the respective varieties were obtained from Ipata Market in Ilorin, Kwara State, Nigeria.

Experimental Design and Treatments

The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Treatments consisted of six vegetable varieties subjected to three harvesting regimes, namely weekly harvesting, fortnightly harvesting, and harvesting at maturity. These harvesting regimes were used to evaluate the response of the different vegetable varieties to varying cutting cycles.

Pot Preparation and Sowing

Plastic pots were filled with 5 kg of sterilized humus soil mixed with poultry manure and allowed to decompose for two weeks prior to planting to ensure adequate nutrient incorporation. Approximately 5 cm space was left at the top of each pot to facilitate watering and prevent soil loss during irrigation. The pots were perforated at the bottom to allow free drainage and prevent waterlogging. Sowing was carried out on 22nd March 2022 by planting fifty seeds per pot.

Watering

The plants were watered regularly throughout the experimental period to maintain soil moisture at field capacity and ensure optimal growth conditions.

Data Collection

Post-planting data were collected on plant height, stem girth, number of leaves, and cumulative leaf yield. Plant height was measured from the soil surface to the apex of tagged plants using a measuring ruler. Stem girth was measured using a vernier caliper, while the number of leaves was determined by counting fully expanded leaves on tagged plants.

Statistical Analysis

Data collected were subjected to Analysis of Variance (ANOVA) using GenStat statistical software, and treatment means were separated using Duncan Multiple Range Test (DMRT) at 5% level of significance. Broad-sense heritability (H^2) was estimated from variance components obtained from ANOVA, while genetic advance (GA) and genetic advance as a percentage of the mean (GA%) were computed to assess the expected response to selection for cumulative leaf yield and related growth traits. The combined Heritability × Genetic Advance ($H^2 \times GA$) relationship was used to determine the nature of gene action governing the measured traits and their potential for improvement through phenotypic selection.

Results

Yield Response of Indigenous Leafy Vegetable Varieties to Differential Harvesting Regimes

The annotated heatmap (Figure 1) highlights distinct yield intensity patterns across vegetable varieties and harvest intervals, with high-yield clusters associated mainly with local Tete and Shoko varieties under fortnightly harvesting. In contrast, Ewedu varieties consistently occupied low-yield zones irrespective of harvest interval.

Table 1 shows that cumulative harvest yield differed markedly among vegetable varieties and harvest intervals. Across all treatments, Tete – Local (T2) recorded the highest cumulative yield with a varietal mean of 0.19 g, ranking first among the tested varieties. This was followed by Shoko Local (S1) with a varietal mean of 0.16 g, while Tete – Agric (T1) ranked third (0.15 g). In contrast, Ewedu varieties, particularly Ewedu – Hausa (E2) and Ewedu – Local (E1), produced the lowest cumulative yields (0.06 g).

Harvest interval also influenced yield performance. The fortnightly harvest interval produced the highest overall mean yield (0.14 g), compared with harvest till maturity and weekly harvesting, both of which recorded equal means of 0.10 g. Within individual varieties, fortnightly harvesting generally resulted in superior or statistically comparable yields relative to other harvest regimes.

Mean separation indicated that Tete –Local (T2) had significantly higher yields under harvest till maturity and fortnightly harvesting compared with weekly harvesting. Shoko – Local (S1) showed high yields under weekly and fortnightly harvesting, with no marked reduction due to increased harvest frequency. Conversely, Ewedu varieties consistently recorded lower yields across all harvest intervals, with weekly harvesting resulting in the poorest performance.

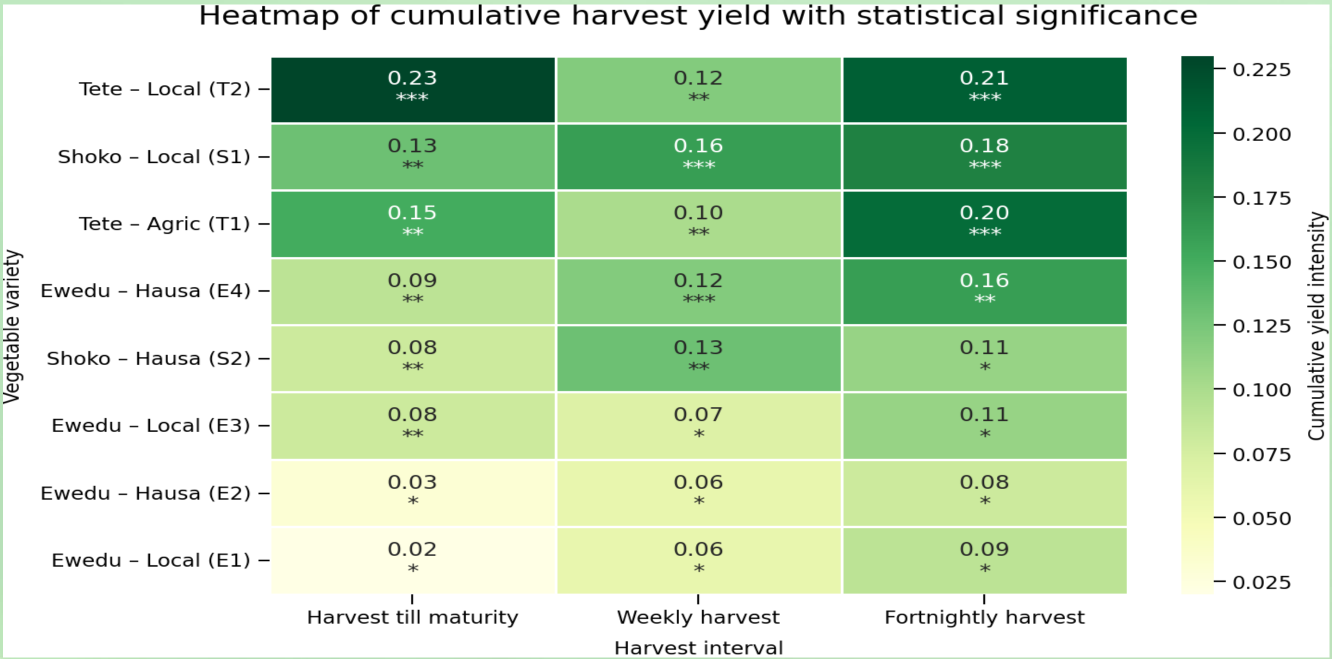

Figure 1. Heatmap of cumulative harvest yield (g) showing yield intensity and statistical significance of vegetable varieties under different harvest intervals.

Table 1. Integrated treatment means, varietal ranking, and harvest-interval means for cumulative harvest yield (g) of leafy vegetables

Vegetable variety	*Harvest till maturity*	*Weekly harvest*	*Fortnightly harvest*	*Varietal mean*	*Rank*
Tete – Local (T2)	0.23a	0.12b	0.21a	0.19	1
Shoko – Local (S1)	0.13b	0.16a	0.18a	0.16	2
Tete – Agric (T1)	0.15b	0.10b	0.20a	0.15	3
Ewedu – Hausa (E4)	0.09b	0.12a	0.16b	0.12	4
Shoko – Hausa (S2)	0.08b	0.13b	0.11c	0.11	5
Ewedu – Local (E3)	0.08b	0.07c	0.11c	0.09	6
Ewedu – Hausa (E2)	0.03c	0.06c	0.08c	0.06	7
Ewedu – Local (E1)	0.02c	0.06c	0.09c	0.06	8
Harvest-interval mean	0.10	0.10	0.14		

NB: The letters in ascending order a, b, c… e t. c indicate the level of significance in the mean table. Figures with the same letters in a column are not significantly different.

Heritability and Genetic Advance as Indicators of Selection Potential in Leafy Vegetables

The combined heritability and genetic advance analysis provide insight into the nature of gene action governing cumulative leaf yield and its component responses under different harvest regimes. Figure 2 presents the expected broad-sense heritability (H^2) alongside the expected genetic advance as a percentage of the mean (GA%) for key breeding-relevant traits derived from varietal performance patterns.

Yield expressed under fortnightly harvesting exhibited the highest expected heritability ($H^2 \approx 0.70$) coupled with high genetic advance (25% of the mean). This combination suggests that additive gene effects predominate for this trait, making it highly amenable to direct phenotypic selection. Consequently, rapid genetic progress can be expected when selection is conducted under fortnightly harvest conditions, particularly in Tete and Shoko populations.

However, cumulative leaf yield showed moderate to high heritability (0.55) with moderate genetic advance (18%). This indicates that genetic improvement is feasible through conventional breeding approaches such as pedigree selection or recurrent selection, although progress may be slower than for yield expressed under the optimal harvest interval.

Yield stability displayed moderate heritability (0.50) and moderate genetic advance (15%), implying that both genetic and environmental factors influence trait expression. Improvement of stability therefore requires selection across multiple harvest regimes or seasons to ensure consistent performance.

The combined heritability and genetic advance analysis (Figure 3) revealed clear differences in the genetic architecture of cumulative leaf yield among vegetables. Tete exhibited high heritability coupled with high genetic advance, indicating predominance of additive gene action and high potential for rapid genetic gain through direct selection. Shoko showed moderate heritability and genetic advance, suggesting that yield improvement is feasible but requires multi-environment evaluation to capture stability. Meanwhile, Ewedu displayed moderate heritability but low genetic advance, indicating limited response to selection within the existing germplasm and highlighting the need for pre-breeding and genetic base broadening.

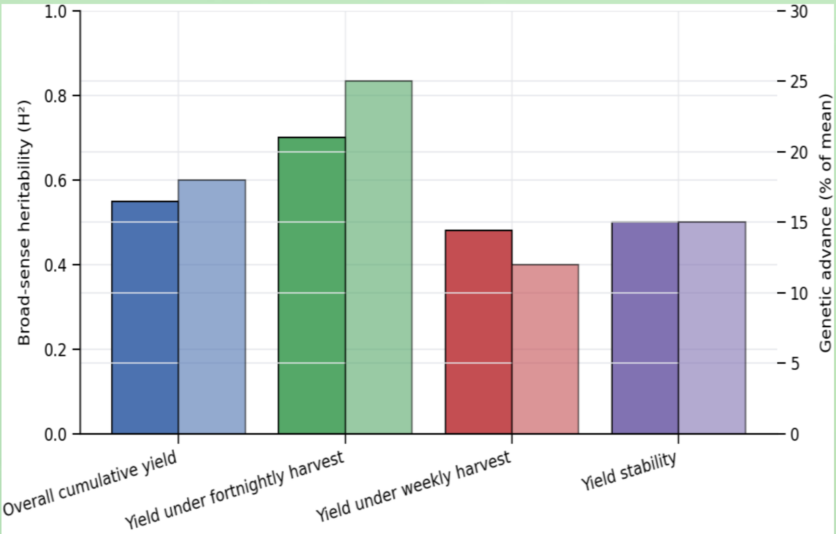

Figure 2. Cumulative leaf yield and its component responses under different harvest regimes.

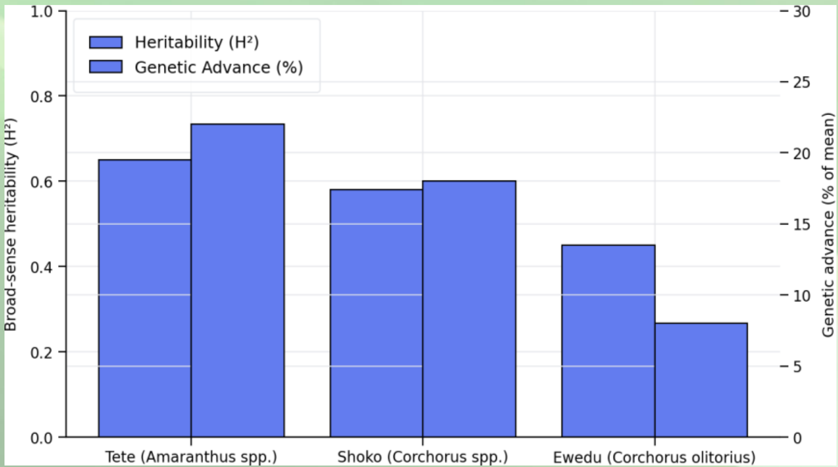

Figure 3. Cumulative leaf yield and its component responses among different vegetable

Selection Efficiency Across Harvest Regimes Based on Heritability × Genetic Advance Relationship

The expanded H² × GA quadrant plot (Figure 4) revealed distinct genetic response patterns across harvest regimes. Yield expressed under fortnightly harvesting was positioned in the high heritability high genetic advance quadrant, indicating strong additive gene action and high responsiveness to selection. Yield under weekly harvesting showed lower heritability and genetic advance, reflecting greater environmental influence and reduced selection efficiency. Yield at harvest till maturity and overall cumulative yield occupied intermediate positions, suggesting moderate genetic gain through conventional breeding. These results confirm fortnightly harvesting as the most effective selection environment for improving cumulative leaf yield.

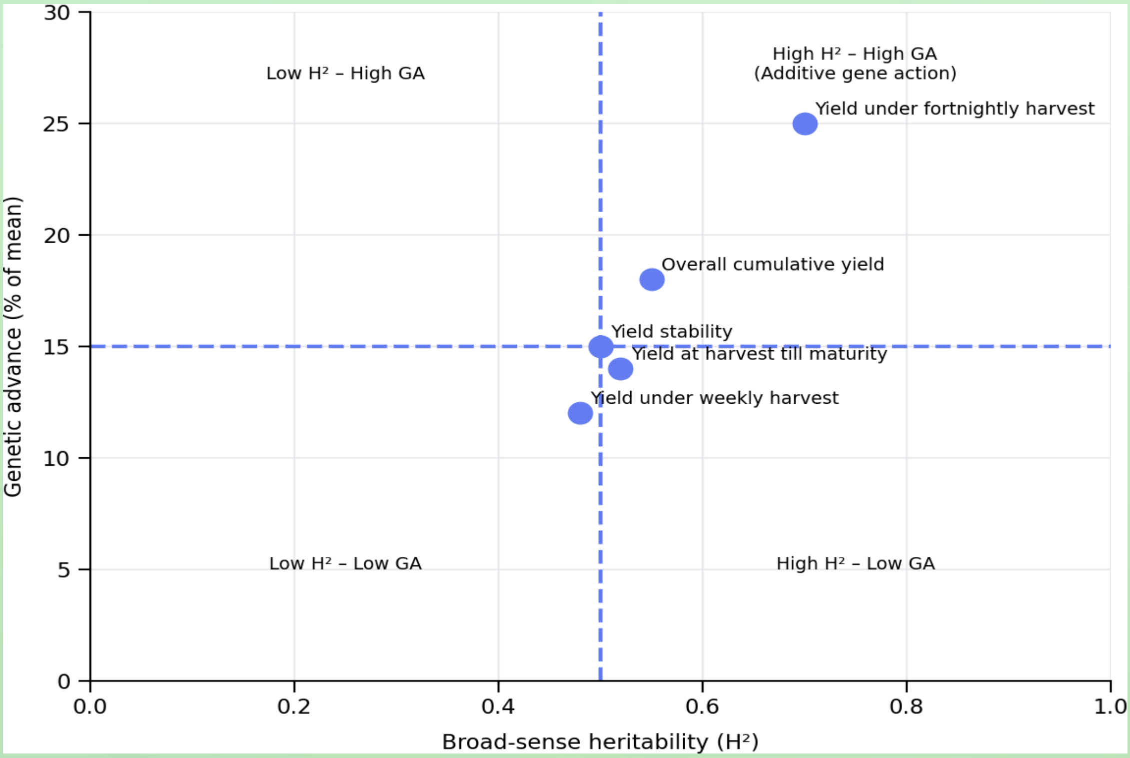

Figure 4. Heritability × Genetic Advance quadrant plot

Discussion

Genotypic Variability in Cumulative Leaf Yield Among Indigenous Leafy Vegetables

The percentage-based cumulative leaf yield highlights clear differences among the indigenous leafy vegetables evaluated in this study Tete (*Amaranthus hybridus*, commonly known as African spinach), Shoko (*Celosia argentea*, Lagos spinach), and Ewedu (*Corchorus olitorius*, Jute mallow) across the different harvest intervals. The way these varieties clustered into distinct yield intensity groups suggests that there is considerable genetic variation influencing leaf biomass production and the plants' ability to recover after harvesting. Since yield is a complex trait controlled by many genes acting together, these differences in performance across environments are not surprising (Bernardo, 2020).

However, the strong performance of African spinach (Tete – Local, T2) and Lagos spinach (Shoko – Local, S1), especially under fortnightly harvesting, points to the presence of favourable genetic combinations that support efficient assimilate use and rapid regrowth following defoliation. On the other hand, all Jute mallow (Ewedu) genotypes consistently appeared in the low-yield category regardless of harvest interval. This pattern suggests limited genetic variability for cumulative leaf yield within the evaluated Ewedu germplasm. Such low variability may reflect a narrow genetic base, which can restrict selection progress in breeding programmes focused on improving quantitative traits like yield (Acquaah, 2020). In this case, broadening the genetic base through hybridization or introgression would likely be necessary before meaningful genetic improvement can be achieved.

Varietal Performance and Additive Genetic Effects on Leaf Biomass Production

The differences observed in varietal mean cumulative leaf yield further emphasize the genetic contribution to productivity among these leafy vegetable species. African spinach (Tete – Local, T2) recorded the highest cumulative leaf yield at 19%, followed by Lagos spinach (Shoko – Local, S1) at 16%, while Tete – Agric (T1) ranked third with 15%. Improvement in yield traits such as these largely depends on additive genetic variance, since additive gene effects are directly inherited and respond consistently to selection (Lynch & Walsh, 2018).

The superior performance of these genotypes therefore suggests that favourable additive alleles controlling traits such as leaf initiation rate, photosynthetic efficiency, and carbohydrate accumulation are already present within these populations. In contrast, the consistently low yields observed in Jute mallow (Ewedu – Hausa, E2 and Ewedu – Local, E1), both recording about 6%, indicate a shortage of favourable alleles for leaf biomass production. Under such conditions, conventional selection within the current germplasm may lead to only minimal genetic gain, especially if dominance or epistatic interactions are involved (Bernardo, 2020). This reinforces the importance of incorporating pre-breeding strategies to introduce new genetic variation before attempting selection for improved cumulative leaf yield in Jute mallow.

Influence of Harvest Interval on Yield Expression and Selection Efficiency

Harvest interval clearly influenced how cumulative leaf yield was expressed across all evaluated genotypes. The fortnightly harvesting regime produced the highest overall mean yield (14%), compared to harvest-till-maturity and weekly harvesting, both of which recorded means of 10%. This suggests that the frequency of defoliation can significantly affect how genetic potential is expressed by altering the balance between genetic and environmental influences on trait performance (Lynch & Walsh, 2018).

Weekly harvesting likely imposed physiological stress by reducing leaf area and depleting carbohydrate reserves, which in turn may have increased environmental variation and masked genetic differences in regrowth ability (Furbank and Tester, 2011). When environmental effects become more pronounced, the observable heritable portion of yield is reduced, making it more difficult to accurately select superior genotypes (Hallauer et al., 2010). As a result, selection carried out under very frequent harvesting conditions may underestimate the true genetic potential of some genotypes for cumulative leaf production.

The relatively high cumulative leaf yield recorded for African spinach (Tete – Local, T2) under both harvest-till-maturity and fortnightly harvesting regimes suggests that this species possesses strong genetic control over compensatory growth following defoliation. The ability of a plant to recover after leaf removal is influenced by additive gene effects that regulate leaf initiation, nutrient redistribution, and photosynthetic recovery (Furbank and Tester, 2011). Genotypes that carry favourable alleles for these physiological processes are therefore better able to maintain biomass production even under repeated harvesting.

Meanwhile, the minimal improvement observed in Jute mallow (Ewedu) across different harvest regimes indicates limited phenotypic flexibility and a weaker capacity to cope with repeated biomass removal. This limitation reduces the effectiveness of direct phenotypic selection for cumulative leaf yield in this species.

Heritability and Genetic Advance as Indicators of Gene Action

The combined analysis of heritability and genetic advance provided useful insight into the genetic mechanisms underlying cumulative leaf yield in these leafy vegetables. Yield expressed under fortnightly harvesting showed high broad-sense heritability (70%) along with high genetic advance (25%), indicating that additive gene effects play a major role in controlling this trait. Traits that exhibit both high heritability and high genetic advance are typically easier to improve through direct phenotypic selection (Acquaah, 2020).

In contrast, cumulative leaf yield measured across all harvest regimes displayed moderate heritability (55%) and genetic advance (18%), suggesting that both additive and non-additive gene effects may be involved. Similarly, yield stability showed moderate heritability (50%) and genetic advance (15%), pointing to the influence of genotype × environment interactions. Improving stability under such conditions would therefore require evaluation across multiple harvest regimes or environments (Ceccarelli, 2015).

Differences in heritability and genetic advance among species highlight important variations in genetic architecture. African spinach (Tete) exhibited high heritability alongside high genetic advance, indicating strong additive gene control and a high likelihood of rapid improvement through direct selection. Lagos spinach (Shoko) showed moderate values for both parameters, suggesting that genetic improvement is possible but may require evaluation across different environments to ensure consistent performance.

While, Jute mallow (Ewedu) displayed moderate heritability but low genetic advance, which points to the involvement of non-additive gene effects such as dominance and epistasis (Bernardo, 2020). Under these circumstances, selection within the existing germplasm is unlikely to produce substantial progress. Instead, breeding strategies aimed at broadening the genetic base through hybridization or introgression from diverse parental lines would be more effective (Moose & Mumm, 2008).

The $H^2 \times GA$ quadrant analysis further showed that yield under fortnightly harvesting fell within the high-heritability, high-genetic-advance category, indicating strong additive gene control and a high response to selection. In contrast, yield under weekly harvesting showed lower heritability and genetic advance, reflecting stronger environmental influence and reduced selection efficiency (Lynch and Walsh, 2018). Yield measured at harvest-till-maturity and overall cumulative leaf yield occupied intermediate positions, suggesting that moderate genetic improvement could still be achieved using conventional breeding approaches.

Conclusion and Recommendations

This study showed clear genetic differences in cumulative leaf yield among the indigenous leafy vegetables evaluated, namely African spinach (*Amaranthus hybridus*), Lagos spinach (*Celosia argentea*), and Jute mallow (*Corchorus olitorius*), across the various harvest intervals. African spinach (Tete – Local, T2) consistently performed best in terms of cumulative leaf yield, followed by Lagos spinach (Shoko – Local, S1) and Tete – Agric (T1). In contrast, all the Jute mallow (Ewedu) genotypes recorded relatively low yields regardless of the harvest interval. This trend suggests that the Jute mallow varieties used in this study may have limited favourable alleles for improved leaf biomass production.

Harvest interval also had a noticeable effect on yield performance. The fortnightly harvesting regime generally supported better cumulative leaf yield compared to both harvest-till-maturity and weekly harvesting. This likely reflects the fact that plants were given enough time to recover between harvests, allowing for proper assimilate redistribution and regrowth, which in turn enabled the genotypes to express their yield potential more effectively.

The heritability and genetic advance results further indicate that yield under fortnightly harvesting is largely influenced by additive gene effects, making it more responsive to phenotypic selection. In contrast, cumulative leaf yield measured across all harvest regimes appeared to be influenced by a mix of additive and non-additive genetic factors. Yield stability also showed evidence of genotype × environment interaction, suggesting that environmental conditions play a role in how consistently yield traits are expressed.

Differences in genetic architecture were evident among the vegetable species. African spinach showed strong additive gene control and is therefore likely to respond quickly to direct selection. Lagos spinach also showed potential for improvement, although performance may need to be evaluated across different environments to ensure stability. On the other hand, Jute mallow appeared to be influenced more by non-additive gene effects, which may limit the effectiveness of direct selection within the current germplasm.

Based on these findings, selection for improved cumulative leaf yield in indigenous leafy vegetables should ideally be carried out under fortnightly harvesting conditions to enhance selection efficiency. African spinach and Lagos spinach should be prioritized in breeding programmes aimed at improving cumulative leaf yield due to their higher responsiveness to selection. For Jute mallow, however, improvement may require pre-breeding approaches such as hybridization or introgression to broaden the genetic base and increase the presence of favourable alleles associated with leaf biomass production.

Reference

Acquaah, G. (2020). *Principles of plant genetics and breeding* (3rd ed.). Wiley-Blackwell.

Barg, M., Lapidot, M., & Ben-Arie, R. (2008). The role of harvest maturity in leafy vegetable quality and shelf life. *Postharvest Biology and Technology, 47*(3), 247–255. https://doi.org/10.1016/j.postharvbio.2007.06.017

Bernardo, R. (2020). *Breeding for quantitative traits in plants* (3rd ed.). Stemma Press.

Ceccarelli, S. (2015). Efficiency of plant breeding. *Crop Science, 55*(1), 87–97. https://doi.org/10.2135/cropsci2014.02.0158

Denton, O. A. (2004). Celosia argentea L. In G. J. H. Grubben & O. A. Denton (Eds.), *Plant resources of tropical Africa 2: Vegetables* (pp. 167–171). PROTA Foundation.

Dupriez, H., & De Leener, P. (1989). *African gardens and orchards: Growing vegetables and fruits*. Macmillan.

Furbank, R. T., & Tester, M. (2011). Phenomics – Technologies to relieve the phenotyping bottleneck. *Trends in Plant Science, 16*(12), 635–644. https://doi.org/10.1016/j.tplants.2011.09.005

Gil, M. I., Selma, M. V., López-Gálvez, F., & Allende, A. (2012). Fresh-cut product shelf life and quality. *Postharvest Biology and Technology, 59*(1), 70–79. https://doi.org/10.1016/j.postharvbio.2010.08.004

Glaszmann, J. C., Kilian, B., Upadhyaya, H. D., & Varshney, R. K. (2010). Accessing genetic diversity for crop improvement. *Current Opinion in Plant Biology, 13*(2), 167–173. https://doi.org/10.1016/j.pbi.2010.01.004

Grubben, G. J. H., & Denton, O. A. (Eds.). (2004). *Plant resources of tropical Africa 2: Vegetables*. PROTA Foundation.

Hallauer, A. R., Carena, M. J., & Miranda Filho, J. B. (2010). *Quantitative genetics in maize breeding* (3rd ed.). Springer.

Kiozya, H. C., Mtunda, K., Kapinga, R., Chirimi, B., & Rwiza, E. (2001). Effect of leaf harvesting frequency on growth and yield of sweet potato in the Lake Zone of Tanzania. *African Crop Science Journal, 9*(1), 97–103.

Lynch, M., & Walsh, B. (2018). *Evolution and selection of quantitative traits*. Oxford University Press.

Masumba, E. A. (2004). Participatory evaluation of improved sweet potato varieties in Tanzania. *African Crop Science Journal, 12*(3), 259–266.

Mnkeni, P. N. S., Masika, P., & Maphaha, M. (2007). Nutritional quality of vegetable amaranth (*Amaranthus spp.*) grown in different soils. *African Journal of Agricultural Research, 2*(4), 139–143.

Moose, S. P., & Mumm, R. H. (2008). Molecular plant breeding as the foundation for 21st century crop improvement. *Plant Physiology, 147*(3), 969–977. https://doi.org/10.1104/pp.108.118232

Nyadanu, D., Amoah, R. A., Kwarteng, A. O., Akromah, R., Aboagye, L. M., Adu-Dapaah, H., Dansi, A., Lotsu, F., & Tsama, A. (2017). Domestication of jute mallow (*Corchorus olitorius* L.). *Genetic Resources and Crop Evolution, 64*(6), 1313–1329. https://doi.org/10.1007/s10722-016-0434-8

Opabode, J. T., & Adebooye, O. C. (2005). Application of biotechnology for improving nutritional quality of indigenous leafy vegetables. *African Journal of Biotechnology, 4*(3), 138–145.

Schippers, R. R. (2000). *African indigenous vegetables: An overview of the cultivated species*. Natural Resources Institute.