Cultivation of okra (*Abelmoschus esculentus* Moench, Malvaceae) in combination with two local varieties of legumes (peanuts and beans) in a school gardening context

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1 ABSTRACT

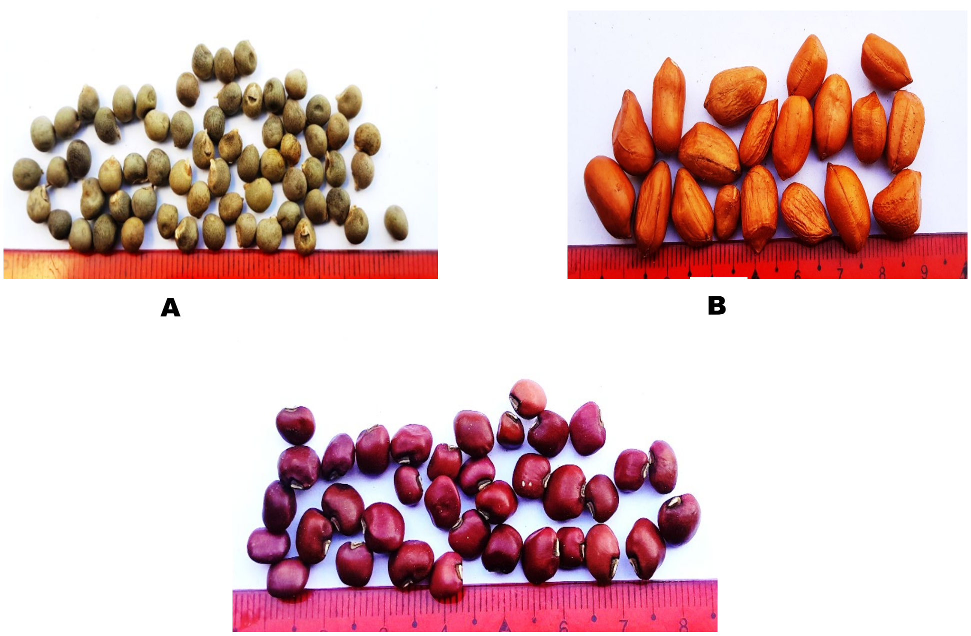
Market gardening contributes significantly to food security in Côte d'Ivoire. Okra (*Abelmoschus esculentus*) is one of the market garden crops grown in most regions of the country. All parts of the plant (roots, stems, leaves, fruits, and seeds) are used for food, medicine, crafts, and even industry. However, the supply of fresh okra pods to the market is severely limited by the lack of arable land, especially in suburban areas. As a result, the price of this foodstuff continues to rise on the local market. The production of okra by students through gardening would be an asset in supplying school canteens with food. Combining this plant with legumes would offer hope for optimizing its yield in a school gardening context. The main objective of this study is to evaluate the yield of the KOTO variety of okra when grown in combination with two types of legumes (peanuts and beans) in a school garden. An experimental plot consisting of three blocks was set up. Each block included the following treatments: okra/peanut combination; okra/bean combination; and okra grown alone. Various growth and yield parameters were measured. The results of these experiments showed that okra grown in combination with peanuts exhibited the highest growth and produced the best yield compared to okra grown alone.

2 INTRODUCTION

For developing countries, food security is one of the most important levers in the fight against poverty and in promoting the well-being of target populations. It relies on crop diversification and improved plant production (Dugué *et al*., 1994; Jean-Marc *et al*, 2015). Raising awareness of this reality at the collective and individual levels necessarily involves schools. Encouraging students to produce food certainly involves implementing gardening in schools (Lhoir, 2009). The production of food crops by learners through gardening could supply school canteens with good quality food at a lower cost. In addition, gardening by students at all levels of secondary education would be an effective way to experiment with the theories taught in various courses related to cultivation techniques (Didier, 2021). The use of agricultural techniques that promote biodiversity and environmental protection, with a view to promoting local products, would be an asset in helping learners understand sustainable development (Arnaud, 2013). This suggests the need to establish a cultivation system suited to the school garden context, conducive to improving vegetable crops. Okra is one of the vegetables with high nutritional value that is quite popular in school cafeteria meals (Hamon 1998). It contains many elements such as calcium, carbohydrates, proteins, vitamins A and C, iron, phosphorus, potassium, and magnesium (Hamon et Charrier, 1985). All parts of the plant (roots, stems, leaves, fruits, and seeds) are used for food, medicine, crafts, and even industry (Marius *et al*., 1997). For okra cultivation in a school environment where the soil has been depleted by successive landscaping projects, it seems important to find a system that optimizes crop yields. Combining legumes with okra (Abelmoschus esculentus) is an agronomic practice that offers several advantages, particularly in terms of improving soil fertility, managing resources, and optimizing crop yields. In Côte d'Ivoire, little scientific research has been devoted to the combination of legumes with okra in school gardens. This study aims to contribute to the success of school gardens by cultivating okra in combination with beans and peanuts.

3 MATERIALS AND METHODS

3.1 Plant material: The plant material used in this study consists of okra seeds (*Abelmoschus esculentus*) of the Koto variety (Figure 1A), peanut seeds (*Arachis hypogaea*) (Figure 1B), and beans (*Phaseolus vulgaris L*) (Figure 1C) of local varieties. All these seeds were collected from the local market. These plants were chosen because they are cultivated by local populations, especially by immigrants and non-native populations. They are also widely cultivated in the school gardens of most educational establishments in the department of Guiglo. This city is located in the west of Côte d'Ivoire in the Cavally region, 510 km from Abidjan.



A B C

Figure 1: Seeds used for cultivation
A. Okra seed, Koto variety; B. Peanut seed, local variety; C. Bean seed, local variety

3.2 Methods

3.2.1 Preparation of the plot: The plot used for the trials was identified at the modern high school in Guiglo in October. Once the plot was made available to us, it was cleared and marked out. The plot was then cleared of dead weeds, ploughed, and labelled.

3.2.2 Sowing: After rainfall, the seeds were sown at a rate of three (03) seeds per seed hole. For the bean and peanut seed combinations, sowing took place between the okra seed holes in a completely randomized block design. Thinning took place 20 days after germination to allow the most vigorous plant in each seed hole to develop.

3.2.3 Maintenance of the plot: After the seeds germinated, weeding was carried out weekly with a hoe to remove weeds and prevent competition. During flowering, insecticides were applied when we noticed pest attacks, especially on okra plants.

3.2.4 Data collection: Agromorphological parameters: Plants from each plot (block) were evaluated using several agromorphological characteristics:

- Plant height (TaP): Plant height was measured using a tape measure once a week from the date of thinning until flowering.

- Number of leaves (NoL): The number of leaves per plant was counted each week from the date of thinning until flowering (Love *et al*., 2023).

- Leaf area (LA): The length and width of the most fully developed leaf were measured using a tape measure. Using the mathematical method developed by Chimi *et al.* (2023), the leaf area of the okra plants was estimated.

$$\text{Leaf area} = \frac{\text{Width x length}}{k}$$

k is a correction coefficient, and in the case of our study, we used k=1.

3.2.5 Yield parameters: The yield of okra in the different types of combinations was estimated using several parameters:

- Fresh biomass (BiF): At flowering, five (05) plants were harvested at random per trial and the fresh biomass of the okra plants was determined using a precision scale.

- Dry biomass (DB): The plants harvested at flowering were dried in the shade for about ten (10) days, then the dry matter mass was estimated by measuring the dry biomass using a scale.

- Number of fruits (NoF): each week, fruits and pods are harvested and estimated per plant until wilting.

- Fruit length (LgFr): the length of the mature fruit was measured using a tape measure.

- Fruit diameter (DFr): this was measured using a caliper (Abobi *et al.*, 2021).

- Fruit weight (WoF): the fruits harvested each week were weighed using a scale and the fruit mass per plant was estimated.

3.2.6 Statistical analysis of data: The experimental setup consists of three blocks measuring 5.5 m x 3 m with three replicates. Each block has 12 sowing points per species and per trial. A spacing of 1 m between rows and 0.5 m between sowing points was used.

The trials carried out per block are as follows:

- Pure okra
- Okra/bean combination
- Okra/peanut combination

Statisca software version 7.5 was used for data analysis. A comparison of means between trials for each parameter was performed using one-way analysis of variance (ANOVA 1). When a significant difference was observed for a trait, the means were separated using the Newman-Keuls test at a 5% significance level.

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4 RESULTS

4.1 Influence of association type on the agromorphological parameters of okra:

During the growth of okra plants, three agromorphological parameters were measured: plant height, number of leaves per plant, and leaf area of the most developed leaf. Okra grown in association with peanuts and beans exhibited different morphological aspects during growth (Figure 2). In general, okra plants grow progressively from the time of thinning, spreading their leaves until they occupy the entire growing space before flowering.

A B C

Figure 2: Okra plants growing in intercropping with beans and peanuts
A: average size of okra in intercropping with beans, B: large size of okra in intercropping with peanuts; C: average size of okra in pure okra cultivation

4.1.1 Changes in the size of okra plants grown in combination with other crops during their growth:

The size of okra plants in each type of combination was recorded during cultivation. The results are shown in Figure 3. Analysis of this figure shows that okra plants increased in size each week from thinning to flowering. In general, okra plants grown in association with peanuts or beans grow faster during the first week than okra plants grown in pure culture. For both types of association, the highest okra plant size was recorded in cultivation with peanuts until the last week before flowering (S3). The lowest value was obtained for okra in association with beans.

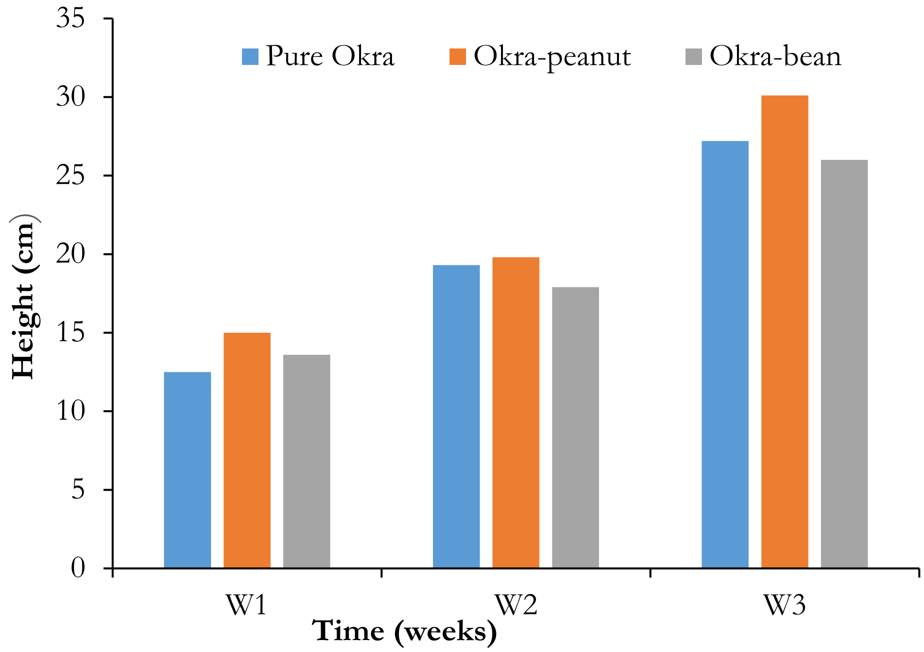

Figure 3 : Size of okra plants grown in association with peanuts and beans
S1: 1st week of culture, S2: 2nd Week of culture, S3: 3rd week of culture

4.1.2 Evolution of the number of leaves of okra grown in association with peanuts and beans: The number of leaves on okra plants increased significantly during the first week after thinning (W1) until flowers appeared (W3). This number rose from approximately 5 leaves at thinning to 9 leaves in the week preceding flowering. In general, the number of leaves on okra plants during their growth remained virtually unchanged for each type of combination tested (Figure 4).

4.1.3 Evolution of the leaf surface area of okra leaves in mixed cropping: The surface areas of fully expanded leaves in okra plants during growth were measured for each type of association. The experimental results are shown in Figure 5. In okra plants associated with peanuts, the surface area of the most fully expanded leaf was the highest, regardless of the stage of growth. The lowest value for this parameter was observed in okra plants associated with beans.

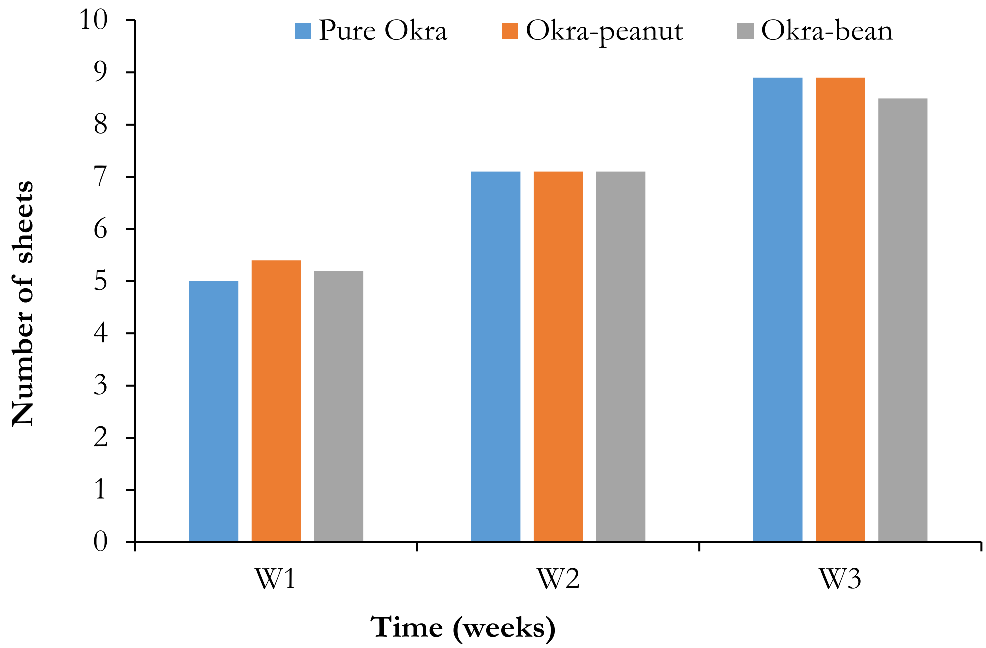

Figure 4 : Number of leaves on okra plants in intercropping
S1: 1st week of culture, S2: 2nd Week of culture, S3: 3rd week of culture

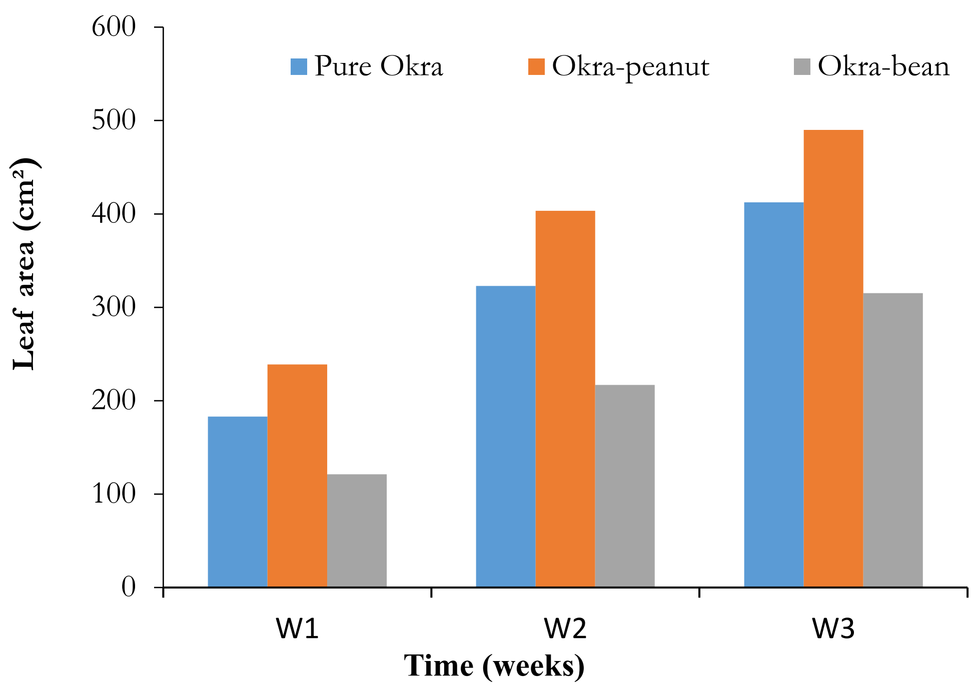

Figure 5: Evolution of the leaf area of okra plants in mixed cropping
S1: 1st week of culture, S2: 2nd Week of culture, S3: 3rd week of culture

4.2 Yield parameters for okra in intercropping

4.2.1 Effect of intercropping type on okra fruit yield: For this experiment, the number and weight of okra fruits harvested were estimated at the end of the growing season. The length and diameter of mature fruits were measured in this experiment. The results obtained are recorded in Table 3. A highly significant effect was observed between crops for the parameters considered in this experiment. The average number of fruits per plant is higher in okra plants grown in association with peanuts and in pure culture than in okra plants grown in association with beans. The average fruit weight of okra plants grown in association with peanuts was the highest compared to that of okra plants grown in monoculture. Okra plants grown in association with beans had the lowest value. The fruits harvested in combination with legumes are large compared to those grown in pure culture (Figure 6). The diameter of these fruits was greater than that of okra grown in pure culture. The highest value was obtained when okra was grown in combination with peanuts.

Table 3: Average values for okra yield parameters

Performance parameters	Type of crop			
	Pure okra	Okra / Bean	Okra / Peanut	*P*
NoFr	10,4±12,44 [b]	20,1±5,48[a]	20,9±5,23 [a]	<0,05
PoFr (g)	74±0,143[b]	87,5±0,147[b]	98±0,193[a]	<0,05
LgFr (cm)	6,75±0,39 [c]	8,21±0,26 [b]	9,70±0,19 [a]	<0,05
DFr (cm)	2,36±0,06 [b]	2,85±0,14 [b]	3,34±0,04 [a]	<0,05

For each row, values with the same superscript letter are not statistically different at the 5% significance level (Newman-Keuls test).
NoFr: Number of fruits per plant, PoFr: Average fruit weight, LgFr: Fruit length, DFr: Fruit diameter

Figure 6: Mature okra fruits harvested from different crops.
A: Small fruits produced by okra grown in pure culture, B: Okra fruits grown in association with beans, C : Okra fruits grown in association with peanuts.

4.2.2 Okra biomass in intercropping: On the different blocks, five (05) okra plants per treatment were harvested in order to measure their fresh weight and dry weight. The results of these measurements are presented in Figure 6. The fresh and dry weights of okra plants grown in combination with peanuts were the highest, followed by okra plants grown in combination with beans. The lowest fresh and dry biomass was obtained from okra plants grown in monoculture.

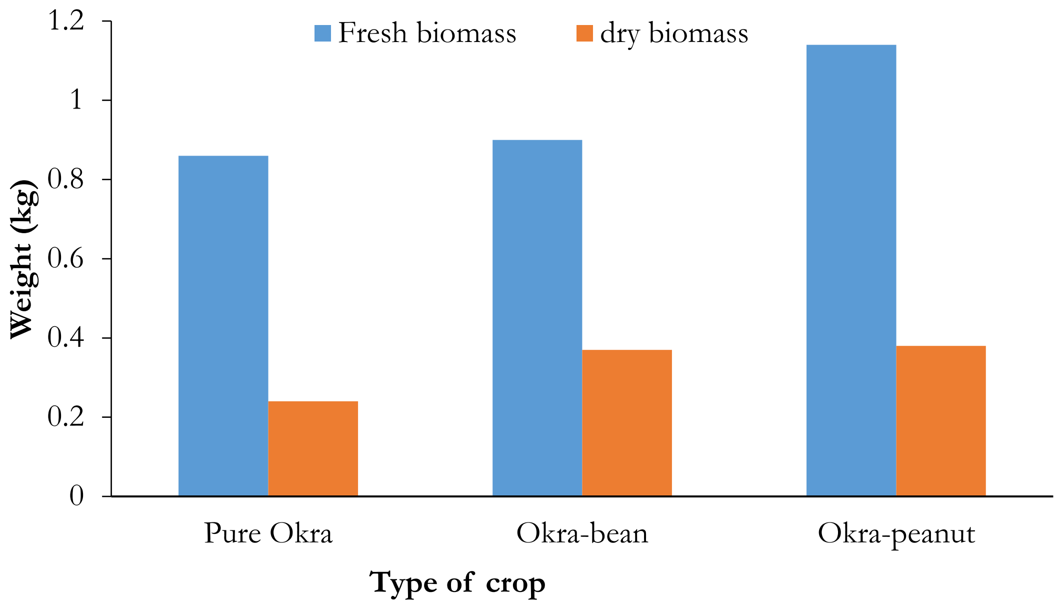

Figure 6: Fresh and dry biomass of okra plants for each type of combination
S1: 1st week of culture, S2: 2nd Week of culture, S3: 3rd week of culture

5 DISCUSSION

The size, number of leaves, leaf area, and biomass of okra varied among the different types of cultivation carried out with two types of legumes. Peanuts promoted rapid growth of okra in intercropping. Indeed, intercropping with legumes can influence the size of cultivated plants due to several agronomic and ecological mechanisms (Brooker *et al.*, 2015). Legumes such as clover and peas form symbiotic relationships with Rhizobium bacteria, thereby increasing the availability of nitrogen in the soil. The subsequent mineralization of this and its absorption by companion plants stimulates the growth of these plants, thereby improving their size and biomass (Brooker *et al.*, 2015). However, in the case of beans, the average size of okra grown with beans increases less rapidly than that of okra grown in monoculture. This could be explained by the fact that the variety of bean grown in our trials is a creeping plant with rapid vegetation that easily occupies space. For these reasons, there could be competition for light between okra and beans, which would have a negative impact on okra growth despite the beans' ability to fix nitrogen from the air through nitrogen-fixing bacteria (Pesson and Louveau, 1984). According to Li *et al.*, (2014), when the density or proximity of legumes is too high, competition for light, water, and nutrients can reduce the size of associated plants. The leaf area of okra was greater when grown in association with peanuts. Nitrogen-fixing legumes improve nitrogen availability for the associated plant, thereby promoting its leaf development. For example, sorghum grown in association with cowpeas increases the leaf area index compared to pure cultivation (Zongo *et al.*, 2021). The combination of corn and beans also increases the leaf area index compared to monocultures (Kalifa *et al.*, 2017). These results are consistent with those obtained with peanuts grown in association with okra in our study. Certain legumes (*Vigna unguiculata*, *Cajanus cajan*, *Arachis hypogaea*) improve soil fertility through nitrogen fixation, thereby promoting okra growth (Olasantan, 2007; Makinde *et al*., 2010). A reduction in competition for nutrients is also observed when okra is grown alongside low-growing legumes such as peanuts (Ndunguru and Thomson, 1994). Thus, yield (number of fruits, pod weight) depends on the interaction between crops. The okra-cowpea (*Vigna unguiculata*) combination has shown an increase in okra yield thanks to better use of resources (Olasantan, 2007). This could explain the higher yield of okra when grown in combination with peanuts. However, with the bean-okra combination, the results are the opposite: here, we observe a smaller increase in the leaf area of the okra plants. This is thought to be due to the rapid growth of the bean plants, which end up smothering the okra plants, creating competition for light. When planting density is too high, legumes can compete with okra for light, reducing its leaf area, photosynthetic activity, and productivity (Olasantan, 2007). Given its growth and high density, beans could compete with okra for water and nutrients, thereby reducing the yield of this plant compared to its pure culture (Matusso *et al*., 2014).

6 CONCLUSION

This study, which evaluates the influence of the okra-legume combination, was initiated in order to optimize the production of this plant in a school garden. Analysis of the results shows that combining okra with peanuts yields the best results in terms of growth and yield compared to combining okra with beans. For the creation of a school garden at the modern high school in Guiglo using okra, we recommend combining it with peanuts. This will enable students to optimize okra harvesting and provide the school cafeteria with natural fruits and pods without the use of chemicals. To better understand certain features of the okra-legume combination, it would be interesting to test several other varieties of okra in intercropping. This will make it possible to determine, for each variety of okra, the appropriate legume for a crop combination that will increase yield.

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8 BIBLIOGRAPHIC REFERENCES

Abobi AHD, Guei AM, Zro BGF and Kacou KTW: 2021. Contribution du vermicompost dans la lutte contre le champignon Rhizoctonia sp: impact sur la croissance de la tomate (Solanum lycopersicum L). Journal of Animal & Plant Sciences, 50 (3): 9093-9107.

Arnaud D: 2013. L'éducation au développement durable: une affaire de représentation? Revue Francophone du Développement Durable (1): 29-58.

Brooker RW, Alison EB, Wen-Feng C and Tim JD: 2015. Improving intercropping: a synthesis of research in agronomy, plant physiology and ecology. New Phytologist, 206(1), 107-117.

Chimi AN, Lekeufack M, Fowoung D, Fotsa JM, Tanetsa AEM, Edzigui MLT and Lhoir C : 2009. Des politiques cohérentes pour soutenir les jardins scolaires. Etopia 7: 251-258.

Didier P: 2021. L'enseignement agricole, entre rénovation et innovation: une dynamique singulière inspirante, Les dossiers des sciences de l'éducation, 46, 103-115.

Dugué P, Rodriguez L, Ouoba B and Sawadogo I: 1994. Techniques d'amélioration de la production agricole en zone soudano-sahélienne: manuel à l'usage des techniciens du développement rural, élaboré au Yatenga, Burkina Faso, 212 p.

Hamon S and Charrier A: 1985. Large variation of okra collected in Bénin and Togo. Plant Genetic Resources-Newletter 56: 52-58.

Jean-Marc M, Aude C, François C, M'hand F, Marianne LB, Marie-Benoît M and Antoine M: (2015). La diversification des cultures: comment la promouvoir? NESE, n° 39, pp. 7-29.

Kalifa C, Alain PK G, Mamadou T, Hassan BN and Michel PS: 2017. Effets des associations maïs-légumineuses sur le rendement du maïs (Zea mays L.) et la fertilité d'un sol ferrugineux tropical à l'Ouest du Burkina Faso. Afrique SCIENCE 13(6): 226 – 235.

Li L, Chen SR and Chen H: 2014. Intercropping alleviates the inhibitory effect of fertilization on nodulation and symbiotic N2 fixation of faba bean. Plant and Soil 323(1-2): 295-308.

Love DC, Uhl MS and Genello L: 2023. Performance of lettuce in closed-loop aquaponics. HortScience 58(6): 719–726.

Makinde EA, Ayeni LS, Ojeniyi SO and Odedina JN: 2010. Effects of Organic, Organomineral and NPK Fertilizer on Nutritional Quality of Amaranthus in Lagos. Researcher, 2, 32-36.

Marius C, Gerard V and Antoine G: 1997. Le gombo, Abelmoschus esculentus (L.) Moench, une source possible de phospholipides. Agronomie et Biotechnologies. Oléagineux, Corps gras, Lipides, 4 (5), 389 - 392

Matusso JM, Mugwe JN and Mucheru-MM: 2014. Effects of different intercropping systems on growth and yield of okra. International Journal of Agronomy 3(3): 162-174

Ndunguru BJ and Thomson JA: 1994. Intercropping okra with legumes: effects on yield and soil fertility. Experimental Agriculture, 123p.

Olasantan FO: 2007. "Effects of intercropping with grain legumes on the growth and yield of Okra (Abelmoschus esculentus)". Journal of Agricultural Science 145(6): 609-615.

Pesson P and Lauveaux X: 1984. Pollinisation et production végétale-Paris. Ed: INRA. 264PP Hamon S: 1998. "Organisation évolutive du genre Abelmoschus (gombo): co-adaptation et évolution de deux espèces de gombo cultivées en Afrique de l'Ouest (A. esculentus et A. caillei)", Ed. ORSTOM, Paris, France, 191 p.

Zongo KF, Hien E, Mare BT and Guebre D: (2021). Performance de l'association mixte sorgho-niébé sur les productivités du sorgho et des sols en zone Soudano-Sahélienne du Burkina Faso. International Journal of Biological and Chemical Sciences 15(3): 987–1005.