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Effect of compost and association (Solanum + Amaranth) on pests and productivity of Solanum macrocarpon

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ABSTRACT

Rapid population growth has led to an increase in demand for agricultural products, particularly vegetables. There is a need to produce ample quantity of vegetables to meet this demand. Among the vegetable crops, gboma (*Solanum macrocarpon*) is the most consumed leafy vegetable in Benin, mainly for its leaves. This study focuses on the effect of compost and the combination of gboma and amaranth on the productivity of gboma. The experiment was conducted at the ValDERA Center of the University of Abomey-Calavi in Benin. It is a randomized Complete Block Design (RCBD) with two factors and six treatments with three replications. No chemical treatments were used for pests and diseases. The results of the trials showed a significant difference in yield between treatments (F=48.09; p<0.05). Treatment T5 (compost 40t/ha+10t/ha and gboma-amaranth combination) gave the highest yield (9.55 t/ha fresh leaves) and differed significantly from the other treatments in terms of yield (p<0.05). The use of composted organic matter in combination with amaranth improved the productivity of gboma compared to conventional urea-based production without chemical control. The combination of amaranth with gboma is an alternative for successful organic gboma production.

Key words: Compost, Crop Association, Yield, Gboma, Amaranth.

INTRODUCTION

The ever-increasing population has led to a growing demand for food globally in the world and in Africa. Almost one third of the population of sub-Saharan Africa, or about 200 million people, suffered from food shortages in 2005. After a decade, the number of people affected by hunger in this part of the world has increased and reached 256.5 million in 2017 (FAO et al., 2018). To meet this deficit, an increase in agricultural production is needed.

Apart from the production of cereals and leguminous crops, fruits and vegetables have also taken an important place in the development of the agricultural sector in many African countries. This is because of their economic profitability (Ahouangninou et al., 2020), their nutritional value, and their latent capacity to be exported on the international market. Vegetable crops are rich in proteins, vitamins, trace elements and antioxidants and therefore have beneficial effects on human health (Singh et al., 2007). According to Lock et al. (2005), 31% of ischemic heart disease and 11% of strokes worldwide are due to low fruit and vegetable consumption.

Benin, like most sub-Saharan African countries, has identified vegetable production as one of the priority sectors to be promoted in the Strategic Plan for the recovery of the Agricultural Sector (PSRSA, 2011-2015)

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and in the Strategic Plan for the Development of the Agricultural Sector (PSDSA, 2017-2025). The production of leafy vegetables is an equally important branch of the market gardening sector because leafy vegetables are important in Beninese gastronomy. In southern Benin, the most produced leafy vegetables are gboma (Solanum macrocarpon), amaranth (Amaranthus cruentus), basil (Ocimum gratissimum) (Ahouangninou et al., 2013). According to Mensah et al. (2019), gboma is a traditional vegetable highly appreciated by the population in southern Benin.

But production of *Solanum macrocarpon* faces many constraints. The most important constraints are the management of pests and diseases that impact productivity and profitability (Assogba-Komlan *et al*., 2007, Ahouangninou et al., 2020). To control pests in Benin, producers most often use chemical pesticides (Ahouangninou et al., 2019). The use of chemical pesticides and fertilizers poses risks to the health of producers, consumers, and the environment (Tomenson and Matthews, 2009; Le Bars et al., 2020).

It is important to look for alternative methods of pest and disease control such as the use of natural plant extracts, biopesticides and crop combinations. Also, production with organic maters can reduce the risk of pollution by chemical fertilizers use. The objective of the study is to evaluate the effects of different doses of compost and the combination of gboma and amaranth on the yield of gboma.

MATERIALS AND METHODS

Study area description

This study was conducted from March to October 2018 at the "Centre de Valorisation des Déchets en Energies Renouvelables et en Agriculture (Centre ValDERA)" of the University of Abomey-Calavi. The University of Abomey-Calavi is in the Commune of Abomey-Calavi in the south of Benin, which has a sub-equatorial climate with temperatures ranging from 23 to 32 °C. The average annual rainfall in this region is 1.245 mm (INSAE, 2012) with two dry and two rainy seasons. The long dry season runs from November to March, followed by the long rainy season which runs from March to July. The short dry season runs from August to mid-September and finally the short rainy season starts in mid-September and ends in October.

Plant material and experimental design

The plant material used in this trial are: Gboma (*Solanum macrocarpon*, local variety) and Amaranth (*Amaranthus cruentus*). Young and vigorous seedlings at four weeks old were used as planting material. To obtain them, a nursery of the two crops was set up separately on 4m² (4m x 1m) beds that had received compost as a bottom dressing. For transplanting, the beds were 4m² in size. The spacing for transplanting is 20cm in all directions. In total, 3 lines of 16 plants are planted for the Gboma. For the associations, there is one amaranth plant between two Gboma plants (32 Gboma plants for 16 amaranth plants).

The trial has two factors (fertilization and cropping system), six treatments (modalities), two of which are controls: (T1) Urea + Gboma, (T2) Compost + Gboma, (T3) Gboma without fertilizer application (natural soil suitability), (T4) Urea+(Gboma+Amaranth), (T5) Compost+(Gboma+Amaranth), (T6) Gboma+Amaranth with no fertilizer application. The crops without fertilizer application are the control treatments. The management of the control plots was similar to that of the other treatments. The trial was set up in a randomized complete block design with six elementary plots or experimental units. Each treatment was repeated three times. Each elementary plot consists of 3 lines of 16 plants. The distance between two consecutive plots is 0.80m. The plots were watered daily to allow the fertilizer and compost applied to start their decomposition before transplanting. The seedlings were transplanted at 0.20m x 0.20m spacing.

Two types of fertilizer were used during the trial, namely compost and urea. For mineral fertilizer, some treatments received a mineral bottom dressing of 160g/plot of 4m² (T1 and T4), others an organic bottom dressing of 4kg/plot of 4m² (T2 and T5). Treatments T1 and T4 received a maintenance fertilizer one week after transplanting at a rate of 75kg/ha. Treatments T2 and T5 received two organic manures at 40 tonnes/ha and 10 tonnes/ha at one and two weeks after transplanting respectively. Treatments T3 and T6 did not receive any manure. The compost used was a mature compost produced from organic household waste mixed with poultry manure. Observations were made every week after transplanting. Observations on pests and plant development were made on 9 identified plants per elementary plot. The information collected are the number of leaves per plant, the surface area of the leaves, the size of the plants, the number of pests and beneficials insects. The data regarding pests such as *Bemisia tabaci*, thrips, aphids, mealy bugs, mites, *Helicoverpa armigera*, Spodoptera sp, *Docilis celepa* and beneficial insects (Colorado beetle, cockroaches) were recorded.

For aphids and mites, the count was coded in discrete variables: (no aphids=0; 1 to 5 aphids= 1; 6 to 20 aphids = 2; 21 to 50 aphids = 3; 51 to 100 aphids = 4; more than 100 aphids = 5). For the nodules on the roots of the plants, the codifications made are: (no nodules=0; 1 to 10 nodules = 1; 11 to 30 nodules = 2; 31 to 60 nodules = 3; 61 to 120 nodules = 4; over 120 nodules = 5).

At the end of the trial, the number of dead plants, the number of harvested plants per bed and the leaf weight per bed were collected.

Data analysis and processing

The information collected after the experiment was introduced into EXCEL spreadsheet and statistical analysis was carried out by the statistical software R 3.4.2.

RESULTS

Evolution of the average size of the gboma plants

The average height (cm) of the plants for the different treatments (T1: Urea + Gboma; T2: Compost + Gboma; T3: Gboma without fertilizer application (natural soil suitability); T4: Urea+(Gboma+Amaranth); T5: Compost+(Gboma+Amaranth); T6: Gboma+Amaranth without fertilizer application) are respectively 34. 01; 31.77; 26.22; 34.19; 35.19; 30.22 cm at day 28 after transplanting (D28) (Figure 1). Treatment T5 recorded the highest average sizes from day 7 to 28 after transplanting.

Effects of treatments on the average leaf area of the plants

The average leaf area per plant in the different treatments (T1: Urea + Gboma; T2: Compost + Gboma; T3: Gboma without fertilizer application (natural soil ability); T4: Urea+ (Gboma +Amaranth); T5: Compost+ (Gboma +Amaranth); T6: Gboma +Amaranth without fertilizer application) are 2.87; 3.30; 2.11; 2.80; 2.83; and 2.60 at D28, respectively. The plants that received the treatment (T2: Compost + Gboma) were those with larger leaves, but the difference between treatments was not statistically significant at 5% level.

Effects of treatments on pest and beneficial insect populations

Treatments with the Gboma+amaranth combination (T4, T5 and T6) recorded higher populations of ladybirds ($p<0.05$) while treatments without the combination recorded the highest populations of mites ($p<0.05$) (Table 1). The T4 and T5 treatments had fewer aphids (0.98 and 0.70 corresponding to 1-5 and 0-4 aphids per plant respectively) compared to the other treatments. The plants with the T5 treatment recorded the lowest number of aphids and mites, but the highest number of ladybirds.

Comparing the treatments to the control T1, all treatments had significantly lower mite and aphid populations (Table 2).

Effects of treatments on the level of nematode infestation

There was a significant difference between treatments in the number of nodules present on the roots of Gboma plants ($p=0.0003$, $F=6.61$). Gboma plants on the plots associated with amaranth (T4, T5 and T6) had fewer nodules on the gboma roots. The gboma plants in treatments T1 and T3 had the most nodules on the roots (1.77 and 1.97 nodules per plant, respectively on average). Treatment T5 had the fewest nodules on the roots of the gboma plants.

Treatment effects on fresh leaf yield of gboma

The ANOVA test revealed a significant difference between treatments in fresh leaf yields of gboma ($p=0.000$, $F=40.91$). Treatment T3 had the lowest yield of gboma (5.75 t/ha). Treatments T6, T1, T4 and T2 followed with yields of 6.22 t/ha, 7.58 t/ha, 7.78 t/ha and 8.88 t/ha respectively. Treatment T5 had the highest yield of gboma plants at 9.55 t/ha or 0.95kg/m2.

DISCUSSION

Commonly grown leafy vegetables in Benin are gboma, amaranth, basil, celosia, cabbage, and lettuce (Ahouangninou et al., 2011). Gboma (Solanum macrocarpon) is one of the most consumed leafy vegetables in southern Benin (Mensah et al., 2019; Ahouangninou et al., 2020). It is mainly produced for its succulent leaves, but in some communities, it is also consumed for its bitter fruits. Gboma leaves are rich in trace elements, minerals and vitamins A, B and C (Afolabi et al., 2020). Amaranth (Amaranthus cruentus) is cultivated for its leaves, which are rich in beta-carotene, calcium, iron, protein, vitamins A and C (Mulokozi et al., 2004).

Amaranth apart from its richness in nutrients is also used in cropping association to reduce the level of pest infestation of associated plants by soil nematodes (Datta, 2006). Crop association is beneficial to producers when well organized as it promotes interactions within the arthropod community according to Yarou et al. (2017). Several research in tropical environments on the effect of crop associations in market gardening on pest populations has been conducted (Assogba-Komlan et al., 2014). Assogba-Komlan et al. (2007) found that plots of cabbage in association with basil (Ocimum gratissimum) plants showed less infestation by caterpillars of the lepidopterans S. littoralis, Plutella xylostella L. and Hellula undalis than those of cabbage grown alone.

In the present study, Amaranth was combined with gboma to evaluate the effect of this combination on the reduction of the pest infestation level. Six treatments resulting from the cross between type of fertilization and the association or not of the plants were evaluated. In all treatments, treatment T5 (gboma+amaranth and compost) had the highest significant gboma plant size at day 28 after transplanting. Treatment T2 (gboma and compost) recorded the highest leaf area, but the difference between treatments taken together was not significant at the 5% level. Regarding crop pests, two of the gboma+amaranth combination treatments (T4 and T5) recorded the lowest aphid populations and all the combination treatments recorded lower mite populations. These same treatments recorded the most predatory ladybirds.

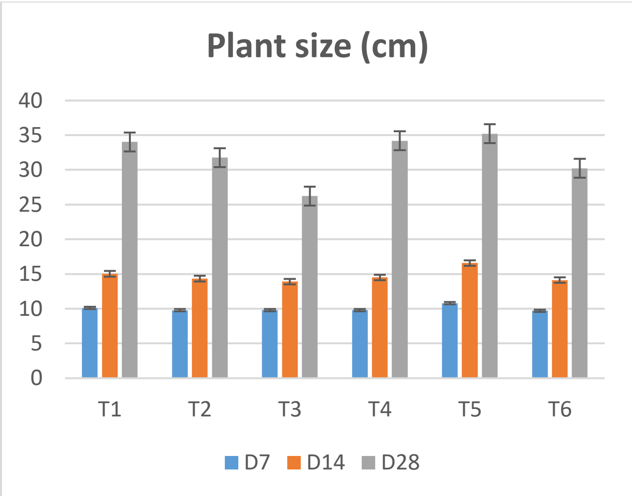

Figure 1: Evolution of the average plant size over time
T1: Urea + Gboma; T2: Compost + Gboma; T3: Gboma without fertiliser application (natural soil ability); T4: Urea+ (Gboma +Amaranth); T5: Compost+ (Gboma +Amaranth); T6: Gboma +Amaranth without fertiliser application

Table 1: Populations of ladybirds, mites and aphids per plant

	Pest population per plant		
Traitements	Ladybirds	Mites	Aphids
T1	0.18a	0.50a	1.49a
T2	0.21a	0.25d	1.21c
T3	0.16a	0.40b	1.20c
T4	0.25b	0.21^{e}	0.98d
T5	0.33c	0.12f	0.70^{e}
T6	0.25b	0.33c	1.29b
F	30.78	210.7	873.7
P-value	0.000	0.000	0.000

Table 2: Effect of treatments on Pests Populations Confint

	Estimate	Std. Error	t value	Pr(>|t|)	2.5 %	97.5 %
Ladybirds~Traitement						
(Intercept)	0.193	0.010	18.524	0.000	0.172	0.215
TraitT2	-0.001	0.015	-0.036	0.972	-0.031	-0.030
TraitT3	-0.027	0.015	-1.814	0.080	-0.057	0.003
TraitT4	0.053	0.015	3.624	0.001	0.023	0.084
TraitT5	0.128	0.015	8.700	0.000	0.098	0.158
TraitT6	0.073	0.015	4.946	0.000	0.043	0.103
Mites~Traitemen						
(Intercept)	0.504	0.009	55.66	0.000	0.486	0.523
TraitT2	-0.243	0.013	-18.922	0.000	-0.269	-0.216
TraitT3	-0.098	0.013	-7.662	0.000	-0.124	-0.072
TraitT4	-0.303	0.013	-23.67	0.000	-0.330	-0.277
TraitT5	-0.352	0.013	-27.47	0.000	-0.378	-0.326
TraitT6	-0.174	0.013	-13.54	0.000	-0.200	-0.147
Aphids~Traitement						
(Intercept)	1.499	0.009	160.31	0.000	1.480	1.518
TraitT2	-0.32	0.013	-24.4	0.000	-0.349	-0.295
TraitT3	-0.308	0.013	-23.3	0.000	-0.335	-0.281
TraitT4	-0.514	0.013	-38.8	0.000	-0.541	-0.487
TraitT5	-0.807	0.013	-61.0	0.000	-0.834	-0.780
TraitT6	-0.202	0.013	-15.3	0.000	-0.229	-0.175

Table 3: Effect of treatments on the number of nodules present on gboma roots

	DF	Sum Sq	Mean Sq	F-value	p-value
Residuals	30	28.63	0.95		
Traitements	5	31.55	6.31	6.612	0.000294
	Mean		Standard-Deviation		Coef Var (%)
T1	1.77a		1.02		57.63
T2	0.89b		0.3		33.71
T3	1.97a		1.5		76.14
T4	0.01c		0.03		300.00
T5	0.009c		0.02		222.22
T6	0.013c		0.05		384.61

Table 4: Fresh leaf yield of gboma

Traitements	Yield (kg/m2)		Yield (t/ha)	
	Mean	Standard-deviation	Mean	Standard-deviation
T1	0.76b	0.25	7.58b	0.25
T2	0.89c	0.53	8.88c	0.53
T3	0.57a	0.61	5.75a	0.61
T4	0.78b	0.47	7.78b	0.47
T5	0.95d	0.15	9.55d	0.15
T6	0.62a	0.15	6.22a	0.15
F		40.91		
P-value		0.0000		

This inverse relationship between ladybird populations and aphid and mite populations is explained by the fact that aphids and mites are prey for ladybirds (Frazer and Gilbert, 1976; Lopes et al., 2012). The association influences pest populations. The same is true for the level of infestation of gboma plants by soil nematodes, as treatments T4, T5 and T6 recorded the least number of nodules on the gboma roots. However, treatment T5 (association and compost) recorded the fewest nodules on the gboma roots compared to the others. These results confirm those obtained by Datta (2006) on the role of amaranth in reducing the infestation of the associated plant by nematodes.

The results obtained on pest populations influenced the fresh leaf yield of gboma. Indeed, the results of the study showed that treatment T5: Compost + gboma and amaranth combination gave a significantly higher yield of fresh leaves of gboma (9.55 t/ha) compared to the other treatments, followed by treatment T2 (8.8 t/ha). The urea treatments (T1 and T4) yielded 7.58 t/ha and 7.78 t/ha. These results are comparable to those of Djaouga et al. (2020), which reported that compost-fertilised gboma had a high yield of 10.5 t/ha compared to the conventional crop with urea and NPK which was 8.75 t/ha.

Compost is the result of recycling organic matter. It is a dark, blackish-brown, fragmented substance that smells like wood. It is humus containing living organisms and minerals that can be used as plant food. Compost reduces the water consumption of vegetables by reducing their transpiration. It also has a stimulating effect on the formation and growth of roots and stems. It accelerates photosynthesis and finally, it improves the health of plants by increasing their resistance to various aggressions and yield (Kitabala et al., 2016; Ministère de la Région Wallonne, 1994). The use of compost also helps to safeguard the environment (Kitabala et al., 2016). Yields with compost fertilizations are often comparable to those of chemical fertilizer in gardening. The agronomic value of municipal waste composts on increasing crop yields has been reported by several authors. N'Dayegamiye et al. (2005) demonstrated the effects of household waste composts on crop yields and certain soil properties, comparing the unamended control with the 20, 40 and 60 t/ha composts. They report that these amendments increased maize seed yields by 1 to 3 t/ha and in proportion to the doses applied in two consecutive years. Compost does increase crop productivity, but only when it is well matured.

Conclusion

The experiment conducted showed that the T5 treatment (compost + gboma + Amaranth) gave a yield of 9.55 t/ha higher than 7.58 t/ha and 7.78 t/ha for the urea-based treatments (T1 and T4) and 5.75 t/ha for the absolute control. Compost is a very rich organic matter that favors the development of plants useful to man and improves the fertility and structure of the soil. The combination of gboma with amaranth reduced pest populations and nematode infestation levels. Growers can be advised to use compost in the gboma+amaranth combination to improve their gboma productivity.

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REFERENCES

Afolabi, S. G., Davidson, J. O., Ibrahim, H. M., Tijani, A. T., & Adeboye, M. K. A. (2020). Response Of Gboma Eggplant To Nitrogen Fertilization In Minna Southern Guinea Savanna Of Nigeria. *Sustainability in Food and Agriculture (SFNA)*, *1*(2), 95-98.

Ahouangninou, C., Martin, T., Bio-Bangana, S., Huat, J., Parrot, L., Vidogbéna, F., ... & Fayomi, B. (2013). Characterization and diversity of the market-gardening production systems and their interactions with urban and peri-urban environment in Southern-Benin, West Africa. *Continental Journal of Sustainable Development*, *4*(1): 24-38.

Ahouangninou, C., Boko, S. Y. W., Logbo, J., Komlan, F. A., Martin, T., & Fayomi, B. (2019). Analyse des déterminants des pratiques phytosanitaires des producteurs maraîchers au sud du Bénin. *Afrique Science*, *15*(5), 252-265.

Ahouangninou, C., Boko, S. Y. W., Arouna, A., Logbo, J., Fayomi, B., & Martin, T. (2020). Performance environnementale et economique dans la production de la grande morelle (Solanum macrocarpon) au Sud du Benin: Une evaluation des efficacites technique, allocative, economique. *Agronomie Africaine*, *32*(2), 135-149.

Assogba-Komlan, F., Prudent, A., Enoch, A., Rachidatou, S., Adrien, B., Charlotte, A., ... & Ayémou, A. (2007). Pratiques culturales et teneur en éléments anti nutritionnels (nitrates et pesticides) du Solanum macrocarpum au sud du Bénin. *African journal of food, agriculture, nutrition and development*, *7*(4), 1-21.

Assogba-Komlan, F., Simon, S., Adjaïto, L., Agbozo, R., Mensah, A., Ahouangninou, C., ... & Martin, T. (2014). Evaluation de l'effet de cinq différentes couleurs de filets anti-insectes sur la lutte contre les ravageurs et la productivité du chou (Brassica oleracea) au Sud-Bénin. *Bulletin de Recherche Agronomique du Bénin*, *76*, 1025-2355.

Assogba Komlan, F., Yarou, B. B., Mensah, A., & Simon, S. (2012). Les légumes traditionnels dans la lutte contre les bioagresseurs des cultures maraichères: associations culturales avec le Tchayo (Ocimum gratissimum) et le Yantoto (Launaea taraxacifolia).

Centre ValDERA. (2016). Effets de l'usage de compost et des digestats sur la production de la grande morelle, Rapport d'activités, Université d'Abomey Calavi, pp: 64.

Datta, S. C. (2006). Possible use of amaranth as catch crop for root-knot nematodes intercropped with okra. *Phytomorphology*, *56*(3), 113.FAO, 2006. The state of food insecurity in the world, Rome, Italy, pp: 44.

FAO, FIDA, OMS, PAM, UNICEF. (2018). L'État de la sécurité alimentaire et de la nutrition dans le monde 2018. Renforcer la résilience face aux changements climatiques pour la sécurité alimentaire et la nutrition. Rome, 218.

Frazer, B. D., & Gilbert, N. (1976). Coccinellids and aphids: a quantitative study of the impact of adult ladybirds (Coleoptera: Coccinellidae) preying on field populations of pea aphids (Homoptera: Aphididae). *Journal of the Entomological Society of British Columbia*, *73*, 33-56.

Kitabala, M. A., Tshala, U. J., Kalenda, M. A., Tshijika, I. M., & Mufind, K. M. (2016). Effets de différentes doses de compost sur la production et la rentabilité de la tomate (Lycopersicon esculentum Mill) dans la ville de Kolwezi, Province du Lualaba (RD Congo). *Journal of Applied Biosciences*, *102*, 9669-9679.

Le Bars, M., Sidibe, F., Mandart, E., Fabre, J., Le Grusse, P., & Diakite, C. H. (2020). Évaluation des risques liés à l'utilisation de pesticides en culture cotonnière au Mali. *Cahiers Agricultures*, *29*(4), 01-09

Lopes Chevalier Mendes, T., Bosquée, E., Polo Lozano, D., Chen, J. L., DengFa, C., Yong, L., ... & Francis, F. (2012). Evaluation de la diversité des pucerons et de leurs ennemis naturels en cultures maraîchères dans l'est de la Chine. *Entomologie Faunistique*, *64*(3), 63-71.

Djaouga, N. T., Diogo, R. V. C., Baimey, H., & Godau, T. (2020). Développement du gboma (Solanum macrocarpon L.) sous l'influence du biochar, de la fréquence d'arrosage et des nématodes à galles en conditions de serre. *Annales de l'Université de Parakou-Série Sciences Naturelles et Agronomie*, *10*(1), 33-40.

Lock, K., Pomerleau, J., Causer, L., Altmann, D. R., & McKee, M. (2005). The global burden of disease attributable to low consumption of fruit and vegetables: implications for the global strategy on diet. Bulletin of the World health Organization, 83(2), 100-108.

Mensah, A.C.G., Sikirou, R.F., Assogba Komlan, B., Yarou, G.S.K., Midingoyi, J., Honfoga, M.E.E.A., Dossoumou, G.N., Kpera, A., & Djinadou, K.A. (2019). Les techniques culturales performantes du gboma pour l'amélioration des revenus des maraîchers au Bénin: Référentiel technico-économique de la production agricole. INRAB, PADMAR, Cotonou, pp: 56.

Ministère de la Région Wallonne. (1994). Etat de l'environnement, volume1, Wallonie, pp: 461.

Mulokozi, G., Hedrén, E., & Svanberg, U. (2004). In vitro accessibility and intake of β-carotene from cooked green leafy vegetables and their estimated contribution to vitamin A requirements. *Plant Foods for Human Nutrition*, *59*, 1-9.

N'Dayegamiye, A., Drapeau, A. R. L. M., & Laverdière, M. R. (2005). Effets des apports de composts de résidus ménagers sur les rendements des cultures et certaines propriétés du sol. *Agrosol*, *16*(2), 57-71.

PSDSA. (2017). Programme Stratégique de Développement du Secteur Agricole au Bénin 2017-2025, version 2017. Cotonou, pp :173.

PSRSA, (2009). Programme Stratégique de Relance du Secteur Agricole au Bénin 2011-2015, version 2009. Cotonou, pp. 170.

Singh, J., Upadhyay, A. K., Prasad, K., Bahadur, A., & Rai, M. (2007). Variability of carotenes, vitamin C, E and phenolics in Brassica vegetables. *Journal of Food Composition and Analysis*, *20*(2), 106-112.

Tomenson, J. A., & Matthews, G. A. (2009). Causes and types of health effects during the use of crop protection chemicals: data from a survey of over 6,300 smallholder applicators in 24 different countries. *International archives of occupational and environmental health*, *82*, 935-949.

Yarou, B. B., Silvie, P., Assogba Komlan, F., Mensah, A., Alabi, T., Verheggen, F., & Francis, F. (2017). Plantes pesticides et protection des cultures maraichères en Afrique de l'Ouest (synthèse bibliographique). *Biotechnologie, Agronomie, Société et Environnement*, *21*(4).