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RESEARCH ARTICLE

OPTIMIZING TRANSPLANTING DENSITY AND FERTILIZERS TYPE TO IMPROVE BLACK NIGHTSHADE (*SOLANUM NIGRUM* L.) PRODUCTION IN COTE D'IVOIRE

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Abstract

Consumed in sauce as a leafy vegetable rich in micronutrients, black nightshade (*Solanum nigrum*) is a cultivated plant in Côte d'Ivoire. In an attempt to boost its low yield, limited by lack of a conventional technical itinerary, the effect of transplanting density and fertilizer type was studied. After transplanting seedlings carrying 3 to 4 leaves at four densities (25, 35, 70, 120 plants/m²), they received four fertilizers [two organic (pig manure and cowmanure), one mineral (NPK) and one unfertilized control] at the experimental field of Nangui Abrogoua University. Plants were regularly monitored, and growth parameters (plant height and diameter, number and size of leaves) and leafy shoot yield were assessed using the analysis of variance test (ANOVA 2). Results showed that an increase in planting density (from 25 to 120 plants/m²) improved plant height (from 24.44 to over 28 cm), leaf area (from 6.71 to 11.9 cm for length and from 4.33 to 6.64 cm for width) and branching (from 5.4 to 6.4 branches/plant). Conversely, it reduced stem radial growth (from 7.7 to 5.98 mm) and the leaves number (from 63.36 to 35.90). About fertilizer type, the longest, thickest stems carrying numerous large leaves occurred on plants fertilized with pig manure, followed by cow manure and then mineral NPK fertilization. Unfertilized control plants showed the weakest growth. At harvest, optimum yields of leafy shoots (1465.58 to 1883.63 kg/ha) were obtained at medium and high densities (70 to 120 plants/m²) respectively. Positive interaction (transplanting density × type of fertilizer) revealed that the best yields of black nightshade leafy shoot (2228 to 3078 Kg/ ha) were obtained when plants were transplanted at high densities (120 to 70 plants / m²) and fertilized with organic fertilizers (pig and cowmanure).

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Introduction:-

Alongside industrial crops, leafy vegetables also play important roles in African agriculture and diets. In Côte d'Ivoire, these crops are grown as market gardens and sold on markets for their organoleptic qualities (enhancing sauces) and wealth of micronutrients, contributing to health (FAO, 1988; Rubaihayo, 1996). This applies to many vegetable gardens, such as vegetable correa (*Corchorus olitorius*), amaranth (*Amaranthus sp*), Guinea sorrel (*Hibiscus sabdariffa*), and black nightshade (*Solanum nigum*). Commonly called "fouet-n'gna" in Baoulé, "fassam-brou" in Malinké and "tchonhon" in Tagbana, the youngshoots of cooked black nightshade are widely consumed in form of leaf sauce, accompanying daily dishes including rice and maizetoh, both in urban and rural areas (Carnot *et al.*, 2017). Several studies have proven black nightshade's importance in reducing malnutrition problems, by providing human bodies with the required quantities of proteins, minerals and vitamins (Tchiegang *et al.*, 2004; Iheanacho *et al.*, 2009).

However, black nightshade production is very limited and yields remain low, despite its advantages. Indeed, as with most plants producing very small seeds, low or very high sowing densities induced by broadcast sowing, associated with no soil amendment when cultivating black nightshade, result in low yields. Since few data are available on improved technical itineraries for market garden crops, especially traditional leafy vegetables, farmers interested in black nightshade cultivation prefer to grow it traditionally. In such traditional systems, inappropriate crop densities due to broadcast sowing and poor soil conditions reduce plant growth and consequently yield (Ndongo *et al.*, 2012). Contrarily to developed countries, these globally inadequate cultivation practices drastically reduce vegetable crop yields in Africa (Teugem, 1999). According to UNICEF (1998), improving agricultural and food systems is crucial in creating a healthy world, both for individuals and ecosystems.

To address these constraints and integrate black nightshade in Africa, it is essential to develop appropriate cropping management techniques by improving soil fertility and appropriate cropping densities in order to enhance yields (Law-Ogbomo *et al.*, 2016). Accordingly, this study aims at analyzing the effect of transplanting density and fertilizer type on black nightshade growth and yield in order to propose optimal cultivation techniques for this crop and therefore enhance its production.

Material and methods:-

Material:

Plant material:

Plant material consisted of healthy black nightshade seeds (**figure 1**) from research center of CNRA in Bouaké (central Côte d'Ivoire).

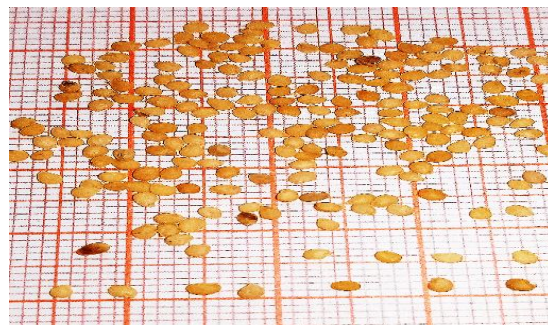


Figure 1. Healthy black nightshade seeds

Fertilizers types:

Three fertilizers including two organic (pig and beef manures) and one mineral (NPK) were used (**Figure 2**).



Figure 2. Different fertilizers: cow manure (A), pig manure (B) and granular NPK (C).

Methods:-

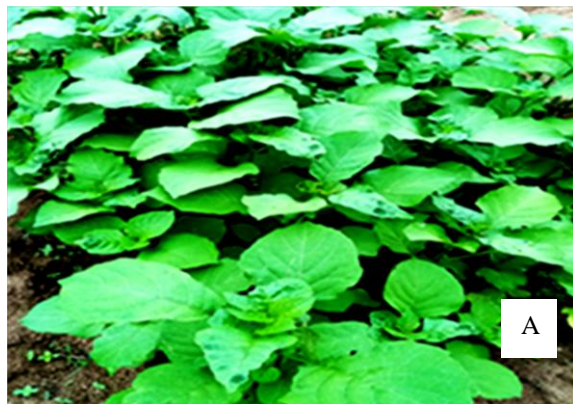
Obtaining vigorous seedlings:

A nursery was set up on a 5 m × 1 m seedbed to produce vigorous seedlings for transplanting. This seedbed was pre-fertilized with pig manure spread over its entire surface and then mixed throughout. Healthy black nightshade seeds were manually sown in the slots dug in the seedbed then covered with a very thin dry soil layer. Nursery maintenance consisted of protecting seedlings from direct sunlight using an oil palm shade, daily watering and manual weeding until vigorous seedlings were ready for transplanting.

Parcel installation: transplanting, fertilization and care:

A parcel measuring 22 m × 15 m, equivalent to 330 m², was established. It consisted of two blocks with 16 plots or seedbeds each, well ploughed. Measuring 2 m × 2 m each, plots were spaced 0.5 m within blocks and 1 m between blocks. In blocks, vigorous 5-leaf black nightshade seedlings, carefully removed from the nursery, were manually transplanted and fertilized. Transplanting consisted of inserting firmly the root zone with the soil clod at a 5 cm depth, then filling it in by compacting the soil all around the collar.

Organic fertilizers (pig and cow manure) were used as a basic fertilization on seedbeds before planting, while NPK mineral fertilizer was applied to the young black nightshade plants two weeks after transplanting (Figure 3). Totally, 32 treatments [4 transplanting densities (25, 35, 75 and 120 plants/m² using equidistance planting pattern of 25 m × 25 m, 20 m × 20 m, 15 m × 15 m and 10 m × 10 m) × 4 fertilizer types (pig manure, cow manure, NPK and unfertilized control) × 2 blocks] were carried out, one per plot. Manual weeding, regular watering and phytosanitary treatment (Cypercal 50 EC) maintained the transplanted and fertilized plants (Figure 3).



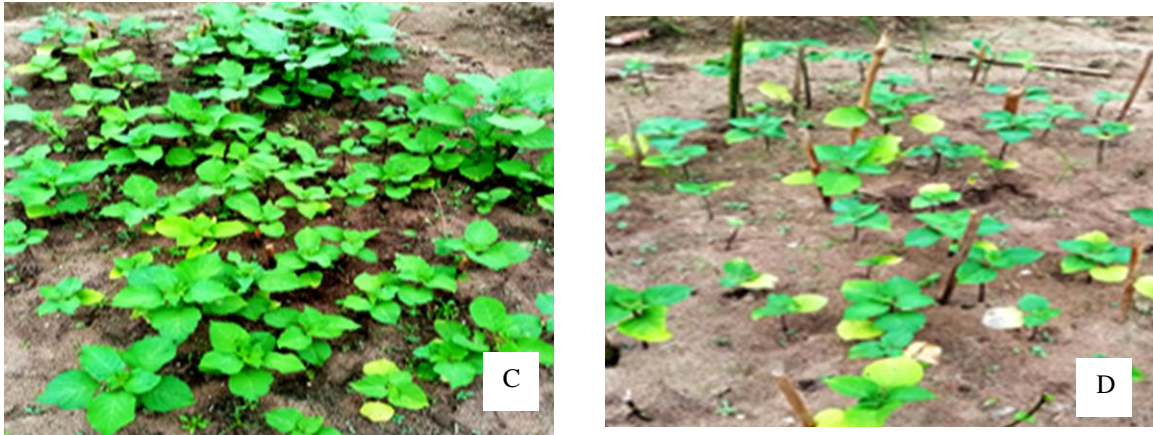


Figure 3. Appearance of black nightshade plants fertilized with pig manure (A), cow manure (B), NPK (C) and control (D), respectively, and all transplanted at the same density (75 plants/ m²).

Harvesting leafy shoots and data collection:

The first harvest took place when plants were sufficiently vigorous, with a height of 20 to 45 cm and young leafy shoots bearing at least 15 leaves. Harvesting consisted of manually cutting the young shoots. These harvested leafy shoots were put together in bunches (Figure 4) to be weighed and then used in cooking as leafy vegetables. Nightshade agro-morphological performance was evaluated through nine quantitative parameters of plant growth and yield. Six of them were related to plant growth and three, to yield. Plant growth was assessed through plant height and crown diameter, leaf and branches number per plant, leaf dimensions (length and width) while yield was evaluated using the number of harvests, weight and number of leafy shoots per plant

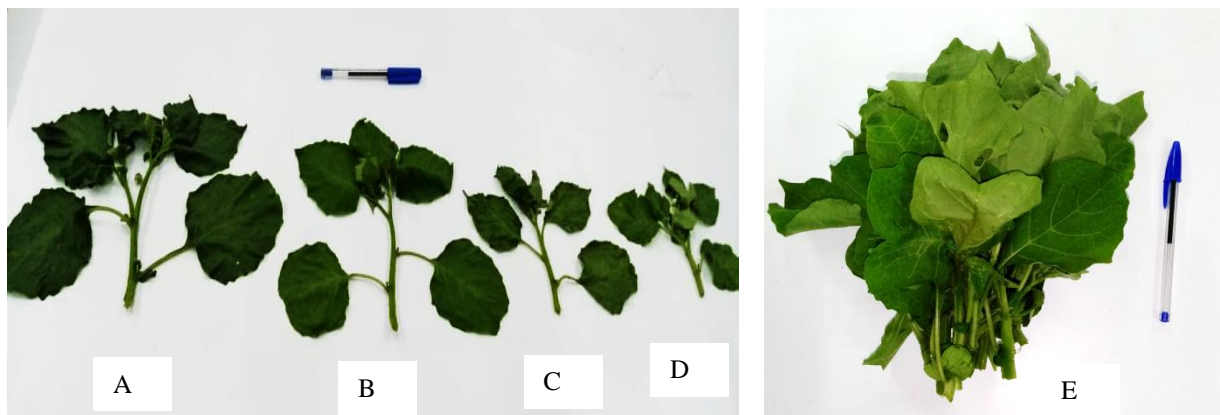


Figure 4. Black nightshade leafy shoots aspect harvested from plants fertilized with pig manure (A), cow manure (B), NPK (C) compared to control (D) and bunches (E).

Statistical analysis:

All the values of plant growth and yield parameters obtained in this study were statistically analyzed. For this, analysis of variance with two criteria classification (ANOVA 2) was carried out, taking into account both analyzed factors (plant density and fertilizer type) individually and their interaction on the means of each parameter. When a significantly different result is observed ($P < \alpha$, $\alpha = 0.05$), the low significant difference (LSD) test is performed in order to distinguish the treatments responsible for these differences (Dagnélie, 1998). All of these analyses were performed using the SAS statistical software (SAS, 2004).

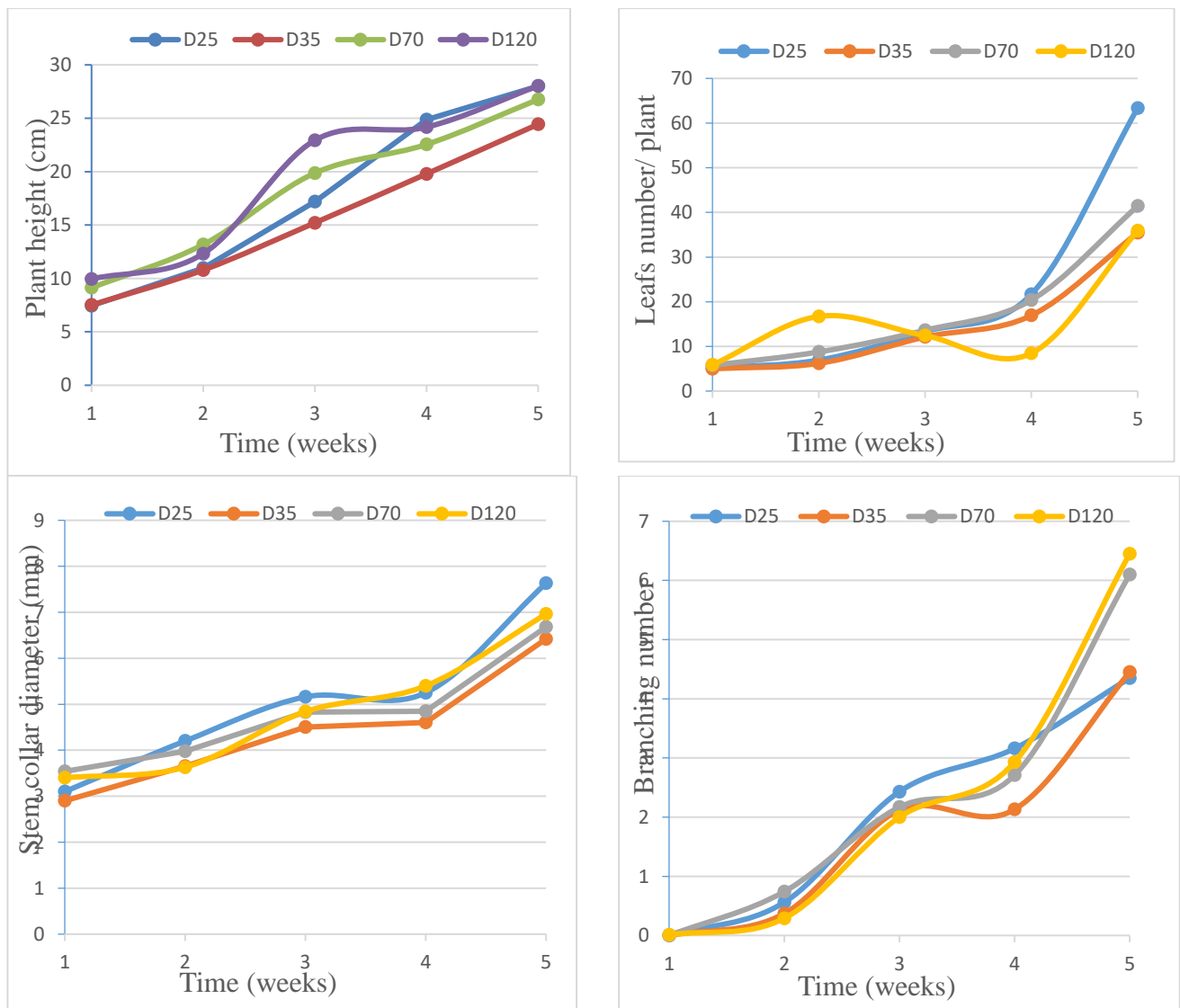
Results:-

Effect of plant density:

➤ **On black nightshade plant growth:**

Overall, **figure 5** analysis showed that black nightshade plants grew steadily over the cultivation period at all transplanting densities (25, 35, 75 and 120 plants/m²). However, weekly comparison of this growth trend showed that its intensity strongly varied depending on the transplanting density over the study period. For example, in the last week (5th), an increase in planting density (from 25 to 120 plants/m²) led to an improvement in plant height (from 24.44 to over 28 cm), leaf area (from 6.71 to 11.9 cm for length and from 4.33 to 6.64 cm for width) and the branches number (from 5.4 to 6.4 branches/plant). Conversely, it reduced stem radial growth (from 63 to 6.42 mm) and the leaves number produced per plant (from 63.36 to 35.90).

In other words, black nightshade transplanting density favored plant height growth, branching and leaf expansion, while reducing the number of leaves and stem thickness growth.



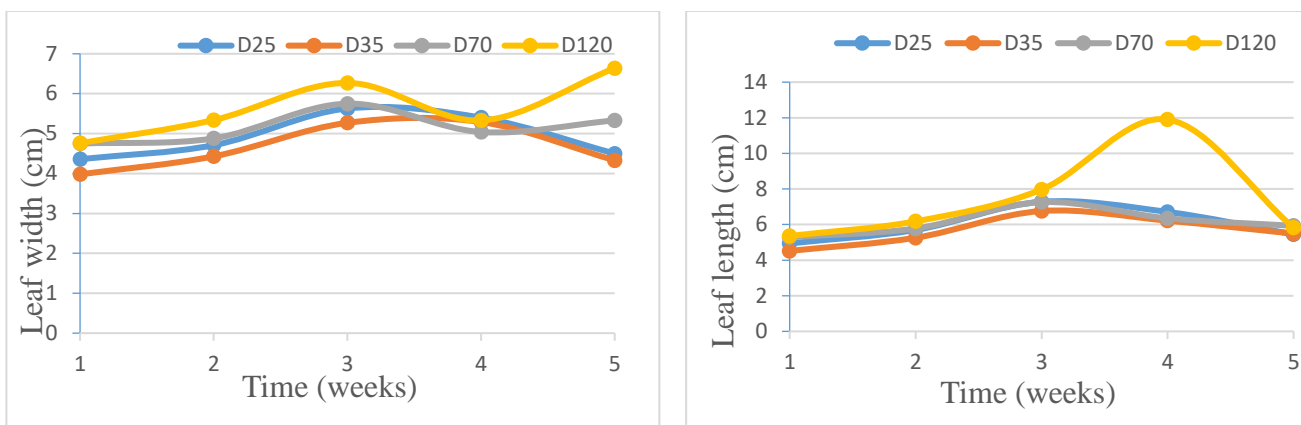


Figure 5. Variation of black nightshade growth parameters following plant density (plants/ m²) over the time

➤ On black nightshade plant yield

Analysis of **table 1** showed that increasing transplant density (from 25 to 120 plants/m²) boosted leaf shoot emission (from 42.5 to 124.25 per plant), global leafy shoot production, as well as increasing harvest numbers (from 2.12 to 3.50) and yields (from 1010.48 to 1883.63 kg/ha). Thus, higher sowing density favors leaf emission and harvesting while considerably improving the yield of leafy shoots in black nightshade.

Table 1. Variation of black nightshade yield and yield parameters following plant density (over the time)

Transplanting density	Yield parameters				
	Number of leafy shoots / plant	Total leafy shoots production (Kg)	Yield (Kg of leafy shoots / ha)	Number of harvests / plant	
25 plants / m ²	42.75±13.16 ^c	776.48±144.12 ^a	1010.48±333.13 ^c	2.12±0.63 ^b	
35 plants / m ²	49.75±16.87 ^c	586.23±160.82 ^b	1021.89±356.39 ^c	2.12±0.63 ^b	
70 plants / m ²	76.25±16.28 ^b	406.25±141.45 ^{bc}	1465.58±402.07 ^b	2.87±0.54 ^{ab}	
120 plants / m ²	124.25±20.84 ^a	419.19±134.96 ^c	1883.63±345.56 ^a	3.50±0.37 ^a	
Statistics	<i>F</i>	18.61	8.83	10.48	5.38
	<i>P</i>	< 0.001	< 0.001	< 0.001	< 0.001

Effect of fertilizers type:

➤ On black nightshade plant growth

Growth parameters (plant height, collar diameter, number of branches/plant, leaf length and width) increased steadily during the growth of black nightshade plants (**Figure 6**). However, plant growth also varied depending on fertilizers used. So, compared to unfertilized controls expressing the lowest growth, best growth was obtained with organic fertilizers (pig manure in first place, followed by beef dung), mean growth with the mineral fertilizer NPK.

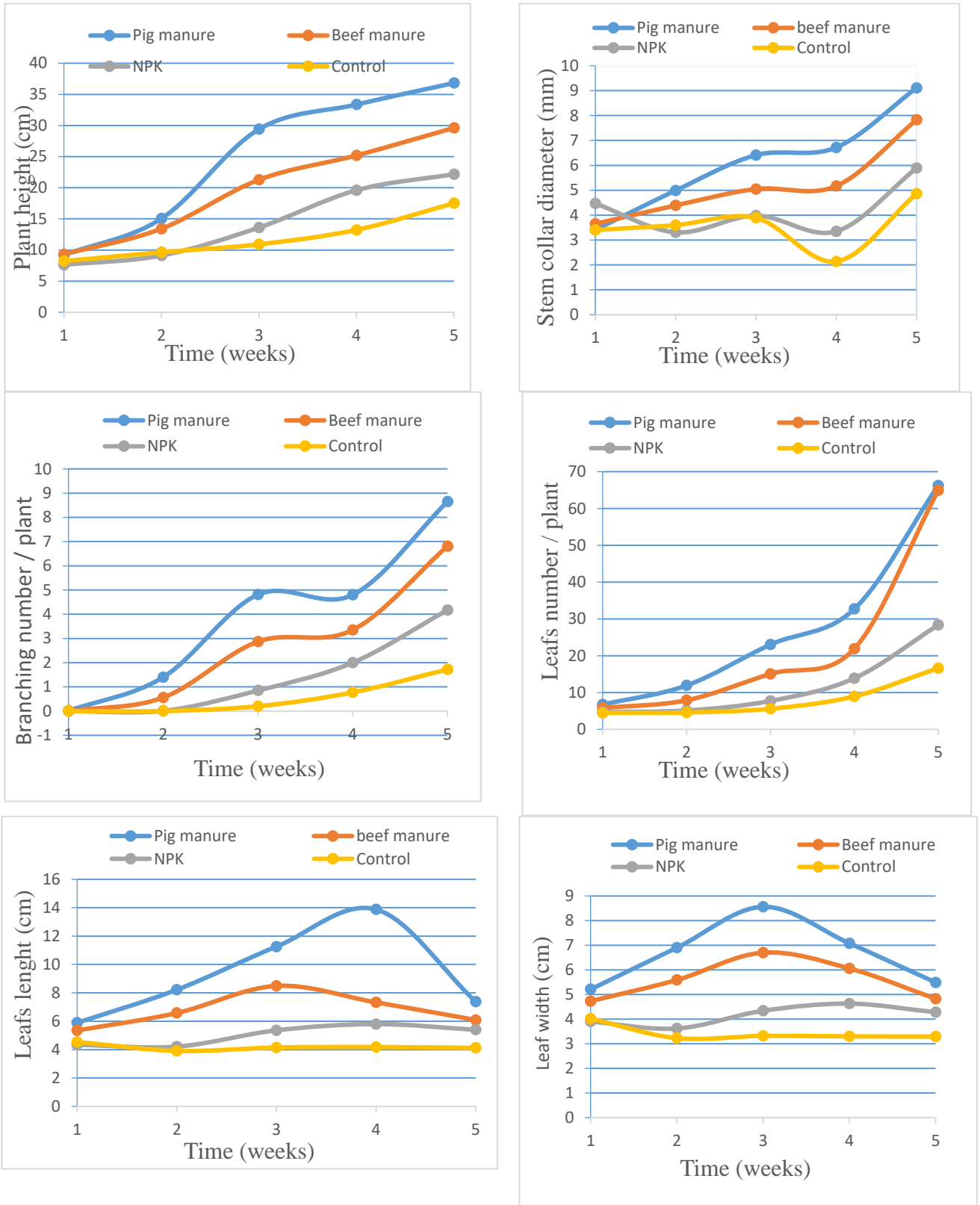


Figure 6. Variation of black nightshade plant growth parameters according to fertilizers type over the time

➤ **Onblack nightshade leafy shootsyield**

Values of black nightshade leafy shoots yield parameters (number of leafy shoots/ plant and their production, number of harvest and yield) significantly varied following fertilizers type (**Table 2**). The higher number (123.25) of heavy leafy shoots (1025.13 Kg) and higher harvest number were produced plant fertilized with pig manure. Furthermore the best yield was obtained with big manure (2562.84 Kg / ha), followed by cow manure (1806.92 Kg/ ha), then NPK (782.39 Kg/ha) that was higher than the control (229.42 Kg/ ha).

In black nightshade, leafy shoots yield varied following fertilizer type. Organic fertilization (pig manure) favor the harvest of best leafy shootsyield.

Table 2. Variation ofblack nightshade leafy shoots yield parameters following fertilizers

Fertilizers type	Yield parameters				
	Number of leafy shoots/ plant	Total production of leafy shoots (Kg)	Number of harvests / plant	Leafy shoots yield(Kg / ha)	
Pig manure	123.25±13.56 ^c	1025.13±67.03 ^a	4.00±0.00 ^c	2562.84±167.58 ^a	
Beef manure	98.37±15.90 ^c	743.30± 76.32 ^b	3.62± 0.18 ^c	1806.92±158.76 ^b	
Engrais NPK	53.62± 14.48 ^a	327.95± 91.47 ^c	2.25± 0.49 ^a	782.39±216.77 ^c	
Control	17.75±12.379 ^b	91.76±66.74 ^d	0.75± 0.49 ^b	229.42±166.87 ^d	
Statistics	<i>F</i>	30.01	51.06	26.58	65.58
	<i>P</i>	< 0.001	< 0.001	< 0.001	< 0.001

Combined effect “plant density × fertilizers type”:-

➤ **Onblack nightshade plant growth :**

Growth parameters [plant height, collar diameter, number of branches/plant, number of leaves and their dimensions (length and width)] regularly increased during black nightshade plant cultivation (**Table 3**). However, for all densities (25, 35, 70 and 120 plants/ m²), the highest growth was obtained with big manure, followed by cow manure, then NPK one. At mean density of 35 plants per m², plant heights were 39.66, 28.48, 23.62 and 15.94 cm, and their ramifications 10.87, 8.08, 6.49 and 5.09 per plant, respectively, for pig manure, NPK and the control (no fertilizer). In addition, the better growth obtained with pig manure fertilization also varied with planting density. Increasing sowing density (from 25 to 120 plants/m²) led to a reduction in plant height (from 39.66 to 36.07 cm), collar diameter (from 10 to 7.82 mm), branching (from 9.75 to 7.57), leaf carrying (from 84.72 to 47.57) and their size (from 7.57 to 6.59 cm for length and from 5.74 to 5.44 for width).

Plant growth not only varied with fertilizer type, but also decreased with transplanting density. Lower transplanting densities and organic fertilization (pig manure) therefore favor the best growth in black nightshade plants.

Table 3. Combined effect of plant density and fertilizers type on black nightshade plant growth parameters

Trans-planting density	Fertilizers type	Plants			Leaves		
		Height (cm)	Stem collar diameter	Branching number / plant	Number/ plant	Lenght (cm)	width (cm)
25 plants / m ²	Pig manure	39.66±1.60 ^a	10.87±0.27 ^a	9.75±0.49 ^a	84.72±3.48 ^{ab}	7.51±0.20 ^{ab}	5.74±0.144 ^a
	Cow manure	28.48±1.74 ^{de}	8.08±0.37 ^{cd}	7.80±0.31 ^{bcd}	124.82±75.73 ^a	6.04±0.30 ^{cde}	4.79±0.23 ^{cd}
	NPK	23.62±1.53 ^{fg}	6.49±0.25 ^d	5.82±0.38 ^{ef}	34.60±4.18 ^{bcd}	5.79±0.27 ^{de}	4.53±0.17 ^d
	Control	15.94±1.03 ^{ij}	5.09±0.14 ^f	3.77±0.49 ^g	9.32±0.86 ^d	3.67±0.21 ^{gh}	2.93±0.18 ^g
35 plants / m ²	Pig manure	37.61±1.34 ^{ab}	9.25±0.27 ^{bg}	8.87±0.35 ^{ab}	71.40±3.76 ^b	7.19±0.19 ^{abc}	5.69±0.13 ^{abc}
	cow manure	29.20±1.39 ^{de}	7.70±0.32 ^d	7.85±0.39 ^{bcd}	42.75±3.68 ^{bcd}	6.57±0.12 ^{cd}	5.07±0.10 ^{bcd}
	NPK	18.74±1.71 ^{hi}	4.84±0.25 ^g	6.72±0.35 ^{de}	16.67±1.67 ^d	4.7±0.23 ^{efg}	3.80±0.19 ^{efg}
	Control	12.20±0.74 ^j	3.90±0.13 ⁱ	0.97±0.14 ⁱ	11.15±0.83 ^d	3.41±0.16 ^h	2.78±0.14 ^h
70 plants / m ²	Pig manure	33.95±1.18 ^{bc}	8.50±0.20 ^c	8.42±0.39 ^{bc}	61.30±3.59 ^{bc}	8.22±1.70 ^a	5.11±0.09 ^a
	Cow manure	32.29±1.36 ^c	8.10±0.31 ^{cd}	6.80±0.57 ^{de}	52.82±3.27 ^{bed}	6.05±0.13 ^{cde}	4.89±0.11 ^{cde}
	NPK	20.39±0.94 ^{gh}	5.60±0.22 ^{ef}	2.27±0.31 ^h	32.72±3.64 ^{bed}	5.11±0.11 ^{ef}	4.10±0.08 ^{ef}
	Control	20.42±1.67 ^{gh}	4.51±0.21 ^{gi}	1.15±0.24 ^{hi}	18.82±1.36 ^{cd}	4.33±0.23 ^{fgh}	3.60±0.19 ^{fh}
120 plants / m ²	Pig manure	36.07±1.70 ^{ab}	7.82±0.30 ^{cd}	7.57±0.46 ^{cd}	47.57±3.85 ^{bed}	6.59±0.17 ^{abcd}	5.44±0.14 ^{bed}
	Cow manure	28.50±1.09 ^e	7.45±0.22 ^d	4.80±0.63 ^{fg}	39.35±2.52 ^{bed}	5.72±0.18 ^{de}	4.58±0.140 ^{de}
	NPK	25.94±1.16 ^{ef}	6.62±0.23 ^d	1.87±0.43 ^{hi}	29.45±2.37 ^{cd}	5.92±0.19 ^{cde}	4.69±0.139 ^{cd}
	Control	21.50±0.91 ^g	5.94±0.21 ^{de}	1.00±0.35 ⁱ	27.25±2.28 ^{cd}	5.07±0.14 ^{ef}	3.87±0.13 ^{ef}
Statistics	<i>F</i>	5.21	11.02	11.63	12.19	2.95	6.93
	<i>P</i>	<0.001	<0.001	<0.001	<0.001	0.04	<0.001

➤ **Onblack nightshade leafy shoots yield**

Values of black nightshade leafy shoots yield parameters (number of leafy shoots/ plant and their production, number of harvest and yield) are listed in **table 4**. Whatever was density (25, 35, 70 or 120 plants/ m²); the highest yield was obtained with pig manure, followed by cow manure, then NPK, higher than the control (unfertilized plants). For example, at low density of 25 plants per m², plant fertilization with pig manure allowed them to produce the best heaviest (891,45 Kg) leafy number (83 per plant) with the best yield of 2228 Kg/ha.

Furthermore, the best yield and yield parameters growth obtained with pig manure fertilization also varied with planting density. So increasing sowing density (from 25 to 120 plants/m²) led to improvement number of leafy shoots harvested per plant (from 83 to 178), their production weight (from 891 à 1231 Kg) and yield (from 2228 to 3078 Kg/ ha). Nevertheless, it did not affect number of harvest that stayed four.

In black nightshade, leafy shoots yield varied with fertilizer type, and increased with transplanting density. Higher transplanting densities and organic fertilization (pig manure) therefore favor harvest of the best leafy shoots yield.

Table 4. Combined effect of plant density and fertilizers type on black nightshade of leafy shoots yield parameters

Transplanting density	Fertilizers type	Yield parameters			
		Number of leafy shoots/ plant	Total leafy shoots production (Kg)	Number of harvests / plant	Leafy shoots yield (Kg / ha)
25 plants / m ²	Pig manure	83.00±2.00 ^{cdef}	891.45±10.76 ^{abc}	4.00±0.00 ^a	2228.63±26.91 ^{bc}
	Cow manure	53.50±5.50 ^{efgh}	496.03±68.34 ^{de}	3.00±0.00 ^{ab}	1240.07±170.85 ^{def}
	NPK	34.50±34.50 ^{fghi}	289.28±289.28 ^{ef}	1.50±1.50 ^{bcd}	573.21±573.21 ^{fgh}
	Control	7.00±0.50 ⁱ	30.15±30.15 ^f	0.50±0.00 ^d	90.30±60.10 ^h
35 plants / m ²	Pig manure	106.50±3.50 ^{cd}	834.01±29.45 ^{bcd}	4.00±0.00 ^a	2085.02±73.62 ^c
	Cow manure	78.00±15.00 ^{cde}	705.39±132.18 ^{cd}	3.50±0.50 ^a	1788.48±355.46 ^{cd}
	NPK	14.50±0.50 ^{fghi}	85.62±39.78 ^f	1.00±0.00 ^{cd}	214.05±99.45 ^{gh}
	Control	10.50±0.50 ⁱ	44.80±44.80 ^f	0.50±0.00 ^d	115.50±80.60 ^h
70 plants / m ²	Pig manure	125.00±0.00 ^{bc}	1143.80±49.38 ^{ab}	4.00±0.00 ^a	2859.50±123.45 ^{ab}
	Cow manure	101.50±10.50 ^{cde}	818.05±64.00 ^{bcd}	4.00±0.00 ^a	2045.13±160.01 ^c
	NPK	65.50±3.50 ^{defg}	321.32±63.41 ^{ef}	3.00±0.00 ^{ab}	803.30±158.52 ^{efg}
	Control	13.00±13.00 ^{hi}	61.75±61.75 ^f	0.50±0.50 ^d	154.38±154.38 ^{gh}
120 plants / m ²	Pig manure	178.50±13.50 ^a	1231.29±106.87 ^a	4.00 ±0.00 ^a	3078.22±267.17 ^a
	Cow manure	160.50±20.50 ^{ab}	953.72±156.33 ^{abc}	4.00 ±0.00 ^a	2153.98±160.48 ^{bc}
	NPK	100.00±22.00 ^{cde}	615.60±44.75 ^{cde}	3.50±0.50 ^a	1539.01±111.88 ^{cde}
	Control	58.00±43.00 ^{defgh}	305.31±305.31 ^{ef}	2.50±1.50 ^{abc}	763.31±599.9 ^{dfgh}
Statistics	<i>F</i>	30.02	50.55	12.58	66.07
	<i>P</i>	< 0.001	< 0.001	< 0.001	< 0.001

Discussion:-

Successful cropping depends not only on using high-quality seeds (Al-Maskri et al., 2004) but also on the technical itinerary followed. As sowing density and fertilizer type are both cultivation practices capable of influencing crop yield (Law-ogbomo *et al.*, 2016), we investigated in this study whether these factors effect on the black nightshade agro-morphological and yield parameters.

Our results showed that both factors, individually and combined, significantly influenced black nightshade plants growth and leafy shoots yield. Therefore, increase in transplant density favored plant growth in height, branching and leaf expansion, whereas it reduced leaf number and stem diameter growth in black nightshade. This may be explained by the competitive situation at high densities for essential growth factors (nutrients, light and water), which leads to reduced plant growth and difficulty in expanding at the soil surface. As a result, they tend to grow taller and branch out more in the quest for light, an essential factor for photosynthesis.

Moreover, Amaglo *et al.* (2006) also reported that increasing planting densities promotes plant growth rates in moringa (*Moringa oleifera*), resulting in taller plants at high planting densities. Besides light, the small diameter of black nightshade stems at high planting densities could be explained by nutritional competition for water and soil minerals. Robinson (1996) already mentioned this phenomenon. Kobenan et al. (2006) also reported a negative correlation between diametric growth and stem height increase. However, production of ready-to-use shoots at harvest was reduced as transplanting density increased in black nightshade. So, at very low and low densities (25 and 35 plants/m² respectively), plant growth, spread and regeneration after each harvest were abundant.

The low level of competition between plants for resources (light, moisture, nutrients) could constitute one explanation. This would enable them to efficiently achieve photosynthesis and consequently produce more leaves at low transplanting density, thereby promoting better regeneration of the black nightshade plants to produce enough leaves. Remisson (1980) noted similar results in cowpea (*Vigna unguiculata*) that yielded more leaves per plant at low planting densities than at high planting densities. Furthermore, this low production of leafy shoots at high density (120 plants/m²) could be explained by the increasing shading between plants, as they grow closer together. As a result, being deprived of light, the plants' basal leaves can no longer participate in photosynthesis. This leads to senescence and eventual death, hence the low number of leaves per plant at this density. Plant compounds production also decreases, making it progressively less able to initiate new leaf formation. Taffouo *et al.* (2008) obtained similar results for cowpea (*Vigna unguiculata*), with a drastic reduction in leaf production with sowing density.

Investigation concerning fertilizer type showed that their nature considerably influenced black nightshade growth parameters. Plants fertilised with pig manure grew the fastest, followed by cow manure. Plants fertilised with NPK showed intermediate growth, while the controls (unfertilised) expressed the lowest growth. Compared with NPK mineral fertiliser, the better performance of organic fertilisers (pig and cow manure) may have two explanations. Firstly, decomposing organic matter improves soil structure (soil flocculation and aeration), promoting root penetration and available mineral uptake. Secondly, organic matter helps build soil colloids, responsible for setting up the soil's clay-humus complexes.

These complexes, once formed, play an active role in soil mineral adsorption in order to prevent leaching after watering or rain, and instead promote their availability for plant nutrition. Sanwal et al. (2007) showed that, as well as stimulating the microorganisms that dissolve minerals and make them readily available in the soil solution for cultivation, the application of organic manure improves aeration and water retention capacity. Indeed, Mulayi (2011) and Kimuni (2014) pointed out that applying organic waste to poor and acid soils provides the necessary nutrients for plant nutrition and growth. This is why organic fertilisers increase crop yields. Olaniyi *et al.* (2010) reported rapid growth in okra (*Abelmoschus esculentus*) grown on soil fertilized with increasing doses of organic fertilizer. Similarly, in Haiti, Artin and Rice (2002) showed that very poor soils were improved by organic manure fertilization, resulting in impressive growth of *Moringa oleifera*. The moderate growth of black nightshade plants achieved with mineral fertilisation (NPK) could be explained by a lack of improvement in soil structure, which did not favour root penetration to enable plants to access mineral elements even though they were available. However, according to several authors (Hgaza et al., 2012; Huber and Schaub, 2011), as mineral fertilisers are composed of water-soluble elements, they do not require any prior mineralisation, which makes them more rapidly available to the plant.

This is why mineral fertilisation generally increases growth rate and production for a given stage of development and favors earliness. However, mineral fertilizers are limited in their effectiveness by the soil. The weak growth and

production we obtained with the NPK mineral fertilizer could be explained by the relatively lower doses applied, certainly due to our poor soil (Bationo and Biolders, 1998), as confirmed by our control without fertilizer. Our results also corroborate Mulaji Kyela's (2011) and Kasongo et al.'s (2013) findings that soil acidity and nutrient deficiency are responsible for the control's low yield. Sadio (2010) also mentioned that tropical soil degradation remains a major challenge that needs to be addressed if the agricultural sector is to be revived and productive, sustainable agriculture developed.

Both transplanting density and fertilization types considerably affected black nightshade plants growth and yield. The good performances (high plant carrying large and wide leaves leading to higher yield of leafy shoots) were obtained with slope sowing and manual weeding followed by chemical one in both varieties. These results can have two explanations. First, plowing through slope sowing improved soil physical properties through its aeration and water retention capacity and looseness for root penetration (Yao-Kouamé and Allou, 2008). Second, the cancellation of competition between interests plants (black nightshade) and other weeds for the soil nutrients available in

Conclusion:-

Fertilizer type and transplant density were studied to determine their impact on growth and yield parameters of black nightshade (*Solanum nigrum*) in order to propose a technical itinerary aimed at optimizing yield and production. Both factors, individually and combined, significantly affect growth and leaf shoot yield. Increasing transplant density (from 25 to 120 plants/m²) led to a reduction in stem collar diameter, number of leaves produced, and overall production, while increasing plant height, number of branches, leaf area, number of leafy shoots, and yield. These results suggest that plants should be transplanted at high densities (120 plants/m²) to optimize yield.

Fertilizers, whether organic (pig or cow manure) or chemical (NPK), improve growth and yield of black nightshade compared to unfertilized soil (control). However, growth and yield are better with organic fertilizers (especially pig and cow manure). Considering both factors (density and fertilizer type), organic fertilizers promote better growth of black nightshade at very low densities (25 plants per square meter) but yield well when grown at high transplant densities (120 plants per square meter). To optimize their yield, farmers in this sector may be advised to transplant plants at high densities while fertilizing the soil with pig manure.

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