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## Effect of fertilizers type and watering methods on the agronomic performance of cucumber (*Cucumis sativus* L.) grown on substrate in southern Côte d'Ivoire

Koffi Bertin YAO<sup>1\*</sup>, Kouassi Joseph KOUAKOU<sup>1</sup>, Koffi ADJOURMANI<sup>2</sup>, Kouadio Laurent KOSSONOU<sup>1</sup> and Tanoh Hilaire KOUAKOU<sup>1</sup>

<sup>1</sup>Laboratory of Biology and Plant Amelioration, Plant Physiology Unit, Department of Natural Sciences, Nangui Abrogoua University, PoBox: 801 Abidjan 02, Cote d'Ivoire.

<sup>2</sup>Ecole Normale Supérieure d'Abidjan, Cote d'Ivoire.

\* Corresponding author; E-mail: [yaokoffibertin@gmail.com](mailto:yaokoffibertin@gmail.com), Tel: +2250707168900

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### ABSTRACT

Cucumber (*Cucumis sativus* L.) is a plant of great importance for food, agriculture, economy and medicine. This importance explains its high demand, intensified by its cultivation conditions, particularly the growing rarity of fertile land and available water. To contribute to this species yield optimization, the effects of fertilizers type [chemical: NPK (12-22-22) and organic: Agribionate] and a control (C) combined to two watering modes (traditional sprinkler and bottle drip) on plants growth and yield have been studied from sowing to harvest. Plant growth (stem length and diameter at the collar, number of leaves and flowers per plant, leaf area) and yield (fruit weight, diameter and length, yield) were assessed. ANOVA2 tests revealed that fertilization (NPK and agribionate) favored plant growth (respectively 34.20 and 37.32 cm in height against 6.67 cm) and increased yield (7498, 66 and 6600.46 Kg/ha against 1558 Kg/ha) with the largest and heaviest fruits (145.69 and 142.80 g) compared to the control (C) that produced the smallest ones (59.35 g). About watering, the bottle drip mode was more beneficial than traditional sprinkler one for cucumber organ growth and plant yield. The interaction (fertilizer type × watering mode) indicated that the best results were obtained with the Agribionate fertilizer watered with the bottle drip method.

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**Keywords:** cucumber, NPK, agribionate, sprinkler, bottle drip, yield.

### INTRODUCTION

The cucumber (*Cucumis sativus* L.) is a widely cultivated plant belonging to the family *Cucurbitaceae*. It is usually grown throughout the tropical and subtropical countries. Harvested at immature stage, its fruits have extremely high metabolic activity (Singh et al., 2018). Indeed, they are a good source of

phytonutrients such as flavonoids, lignans, and triterpenes, which have antioxidants, anti-inflammatory anti-cancer benefits. The peel and seeds constitute the cucumber most nutrient dense parts. In addition, these seeds are a good source of minerals and used in diet and disease treatment programs (Murad and Nyc, 2016). This explains why cucumber is one of

the creeping vegetables with large consumer demand worldwide (Petre et al., 2015). World's cucumber production is over 40,000 tons, China being the leading producer (Abdul and Khan, 2015). Cucumber has a short storage life, about 10 to 14 (2 to 3 weeks) days at 10 - 12° C and 80% RH (Liu et al., 2020).

In Côte d'Ivoire, market cucumber production is hampered by numerous constraints such as difficult access to land, high pest pressure, climate change (especially the increasing scarcity of rainfall) and, above all, declining soil fertility due to overexploitation (Kouakou et al., 2019). According to Drabo (2016), market gardening including cucumber is profitable and provides a living for many families, especially those living under the poverty line. In addition, cucumbers are the least caloric foods. Remineralising and moisturising, it provides a wide range of vitamins and minerals (more concentrated in its skin). Well-endowed with fiber, it helps to ensure proper intestinal transit (Kroll, 2010). Despite its many socio-economic and nutritional benefits, the annual production of cucumbers about 30,000 tons doesn't fulfill needs (Abdul and Khan, 2015).

According to Al-Far et al. (2019), cucumber is a very demanding species in terms of culture conditions. However, if an adequate technology is applied, it can bring obtained yields with important benefits. Cucumber can be planted directly through seeding or transplanting (Singh et al., 2018). As a rule of thumb, the soil is usually the most available growing medium for plants because it provides anchorage, nutrients, air, and water for successful plant growth and for microorganisms (Sepetri et al., 2018). However, the crops on soil encounter major problems due to pathogen attacks and soil limiting factors (Petre et al., 2015). This is truly the case of the Abidjan city (Côte d'Ivoire), a megalopolis which most vegetable production is provided by peri-urban cultivation. Peri-urban agriculture is facing enormous difficulties, particularly the scarcity of land due to the enormous pressure of urbanisation and environmental pollution (Kouakou et al., 2015). Besides, other problems such as

nematodes, unsuitable soil reaction, unfavorable soil compaction, poor drainage, degradation due to erosion, salinity, etc. all reduce yield (Bacye et al., 2019). In addition, conventional growing crops in soil open field agriculture are somewhat difficult as it involves large space, many workers and a large volume of water (Asaduzzaman et al., 2015). Weed control that could not be avoided is another major problem (Hussain et al., 2014).

Soilless culture or control substrates culture is one of the modern techniques. They are considered as important technologies for better water use efficiency as well as high good quality and quantity products. Indeed substrates, solely or mixed appropriately; provide better root system conditions, compared to those offered by agricultural soil (Wilkinson et al., 2014). However, the selection of a particular material as a substrate depends on its availability, cost and local experience on its use (Sahin et al., 2004 and Al-Far et al., 2019). In Côte d'Ivoire, although different substrates are locally available, their cost makes them difficult to access for all. For this reason, natural substrates (soil) and organic fertilizers are still widely used (Kouakou et al., 2020). Furthermore, the increasing need for food with the increasing population necessitates the effective use of water resources (Sahin et al., 2004; Uzen et al., 2016, Aksoy, 2012). Serious factors such as the misuse of resources, unplanned industrialization, and the release of domestic wastes into the nature increasingly pollute the potable and available water resources (Putra and Yuliando, 2015). Therefore, employing alternative food production systems in future agricultural productions are also of paramount importance (Saha et al., 2016). The advantages of cultivation on soilless consist of an effective monitoring of medium of culture, in particular irrigation and nutrition (Kennard et al., 2020).

This study aimed at testing the effect of fertilizer type (mineral and organic) and watering method (traditional sprinkle and bottle drip) on cucumber growth and yield in order to eventually choose the best combination that enhance its production.

## MATERIALS AND METHODS

### Materials

The plant material comprised seeds of *Poinsett* variety (Figure 1) of cucumber (*Cucumis sativus*, L).

### Experimentation: plot establishment, experimental device and plants monitoring

The experiment was conducted during the dry season (from February to March 2020) in order to avoid any interference with rainwater at the Nangui Abrogoua University experimental field in Abidjan district (Côte d'Ivoire).

The experimental sowing device (parcel) was a surface area of 133 m<sup>2</sup> (19 m x 7 m). It consisted of 24 seedbeds of 1 m x 2.5 m each one. This parcel setting up began with the removal of soil using a hoe and a machete. After plant debris drying, they were collected and burnt. The future seedbeds, receiving the sowing bags, were marked out with wooden stakes. Three types of substrates intended to receive the seeds, then the plants, have been prepared based on a humus-bearing forest soil. They were S<sub>NPK</sub>: forest soil + NPK (99.4% and 0.6% of weight), S<sub>Agri</sub>: forest soil + Agribionate (90 and 10 % of weight) and S<sub>cont</sub>: only forest soil as control. S<sub>NPK</sub> and S<sub>Agri</sub> were respectively mineral and organic fertilizers. Perforated sowing bags (Ø = 12 cm x 15 cm height), intended to receive the sowing seeds, were filled with each of these 3 substrates. These substrates were abundantly watered two days before sowing.

Sowing was carried out using two seeds per hole to 2 cm depth in each bag then covered with soil. From sowing to harvest, two types of watering were applied to each substrate: traditional sprinkler watering (TSW) and bottle drip watering (BDW) using a bottle suspended from a wire on the plant stake. Since 1.5 L of water was needed for 24 hours, watering with a traditional watering sprinkler and drip through hanging bottles were performed every morning. The same amount of water (1.5 L/day) was provided to the plants whichever the substrate and the watering method. On the whole, 24 treatments (3 substrate types x 2 watering methods x 4 replicates) were used. Sowing bags were placed in 2 rows of 6 lines per seedbed.

In order to prevent competition, weeds and herbs, which could host the cucumber

parasites, were removed manually from the bags containing the plants and with a hoe between the bags placed on the seedbeds. At 30 days after sowing, an insecticide (Cypercal 50 EC) was sprayed on all parts of the plant by the hand sprayer in order to eliminate all potential defoliating insects and seedling pests.

Due to the climbing character of cucumber, each plant was staked with a string on the bamboo trellis as early as the first tendril appeared (Figure 2). Generally, staking role is to improve fruit quality, to reduce diseases frequency through better air circulation in the crop, and to facilitate fruit harvest.

### Data collection

The agromorphological performance was evaluated through 9 parameters of plant growth and yield. These were quantitative parameters of which five were morphological and four related to yield. Morphological parameters related to plant height, stem diameter at collar, number of leaves and flowers per plant and leaf area (LfAr). Leaf area was evaluated from the largest leaf according to the formula of Blanco and Folegati (2003) for cucumber:

$$LfAr = 0,851 \times L \times W$$

Where the length (L) of the largest leaf is the distance from the tip of the petiole to the apex and its width (w) at mid-length, using the following formula:

The yield was evaluated through the number of fruits per plant, the length, diameter and weight of each fruit at harvest (Figure 3).

### Statistical analysis

All the values of the plant growth and fruits yield parameters obtained in this study were statistically analyzed. For this, analysis of variance with three criteria classification (ANOVA 3) was carried out, taking into account the three analyzed factors (fertilizer type, watering method and experimentation duration) 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).



**Figure 1.** Seeds of cucumber (*Cucumis sativus*, L) Poinsett variety.



**Figure 2.** Aspect of cucumber plants (*Cucumis sativus*) watered by bottle drip (a) and traditional sprinkler.



**Figure 3.** Cucumber plant carrying mature fruits ready to be harvested.

## RESULTS

### Effect of fertilizer type on cucumber plant growth and yield

#### *Effect on plant growth*

The fertilizer type influenced very significantly ( $P < 0.001$ ) the growth parameters of cucumber plants over time (Table 1). Indeed, from the 15<sup>th</sup> to the 35<sup>th</sup> day after sowing, plant height increased from 6.08 to 34.21 cm with NPK, from 6.59 to 37.32 cm with Agribionate and from 2.60 to only 6.69 cm with the controls. However, on day 35, the tallest cucumber plants were observed on the Agribionate substrate (37.32 cm), followed by those on the NPK (34.21 cm) compared to the control substrate which produced the shortest plants (6.69 cm). Similarly, the highest leaves number per plant, the longest, widest leaves with the largest leaf area and the stem largest diameter at collar was observed on plants grown on the substrate containing Agribionate followed by those of the NPK contrarily to the control ones which showed the lowest growth performance.

Thus, cucumber fertilization enhanced plant growth in height and stem diameter, leaf emission and expansion, especially with organic fertilizer (Agribionate) followed by chemical one (NPK).

The good performance of cucumber plants, acquired during the growth phase, also favored flowering. Thus, Agribionate resulted in the best flower production (19.60 flowers per plant) followed by NPK (16.36 flowers per plant). On the other hand, the control showed the lowest flower production (0.98 flowers per plant).

#### *Effect on plant yield*

At harvest, yield and yield parameters were all very significantly ( $P < 0.001$ ) influenced by fertilizer type (Table 2). Indeed, the greatest number of fruits per plant (2.65 and 2.22), the biggest fruits in diameter (4.28 and 4.11 cm), length (14.43 and 16.19 cm) and weight (138.89 and 149.25 g) were produced by plants grown on Agribionate and NPK fertilizers respectively. These treatments provided the highest fruit yields (7498, 66 and

6600.46 Kg/ha). On contrast, the control without fertilizer produced the lowest number of fruits per plant ( $< 1$ ), the smallest fruits in diameter (2.84 cm), length (8.95 cm) and weight (60.08 g) and also the lowest yield (1558 Kg/ha). Thus, organic or chemical fertilization improves fruit production and therefore cucumber yield.

### Effect of watering methods on cucumber plant growth and yield

#### *Effect on plant growth*

The watering methods influenced very significantly ( $P < 0.001$ ) the cucumber plants growth parameters over the time (Table 3). Indeed, from the 15<sup>th</sup> to the 35<sup>th</sup> day after sowing, plant growth was higher (from 6.25 to 36.43 cm) when watering by bottle drip than that of traditional sprinkler watering (from 4.83 to 22.29 cm). Furthermore, on day 35, drip watering favored the tallest cucumber plants (36.43 cm *versus* 22.26 cm), the highest leaves number per plant (14.79 *versus* 10.19) the longest (10.13 *versus* 7.15 cm), widest leaves (12.26 *versus* 8.77 cm) with the largest leaf area (94.12 cm<sup>2</sup> *versus* 79.16 cm<sup>2</sup>) compared to the traditional sprinkler watering. Nevertheless, stem diameter to collar being similar for both watering methods (14.47 cm for bottle drip and 14.28 cm for traditional sprinkler), cucumber plants' watering methods didn't affect their diameter. Thus, cucumber plant watering with bottle drip enhanced their growth, their leaf emission and expansion compared to the traditional sprinkler watering.

The good performance of cucumber plants, acquired during the growth phase, didn't affect flowering because both watering methods (bottle drip and traditional sprinkler) produced the same blooms number per plant (respectively 14.47 and 14.78).

#### *Effect on plant yield*

After harvest, values of cucumber yield and yield parameters following plant watering methods are mentioned in Table 4. Globally, plants watered by drip bottle tended to produce a great number of fruits per plant (2.23), big fruits in diameter (4.06 cm), length (14.72 cm)

and weight (132.64 g) which lead to high yield (5895.65 Kg/ ha). On contrast, plants watered by traditional sprinkler tended to produce a low number of fruits per plant (2.01), small fruits in diameter (3.75 cm), length (13.00 cm) and weight (118.73 g) and lead also to low yield (4589 Kg/ha). Indeed, drip bottle watering tended to improve cucumber yield and yield parameters. Nevertheless, all these tendencies were not statistically significant ( $P > 0.05$ ).

### **Combined effect of fertilizer type and watering method on cucumber plant growth and yield other the time**

#### ***Effect on plant growth***

The growth parameters of cucumber varied very significantly ( $P < 0.001$ ) following fertilizer types combined to watering methods over the time (Table 5). Whatever was fertilizer type (NPK, Agribionate or control), from 15<sup>th</sup> to 35<sup>th</sup> day after sowing, plant height increased significantly for both watering methods (bottle drip and traditional method). For example, when fertilizer was NPK, plant height increased from 6.63 to 39.66 cm with bottle drip watering and from 5.42 to 27.71 cm with traditional sprinkler watering. Comparison of both watering methods on 35<sup>th</sup> day showed that drip watering provided higher plant height (39.66 cm) than the traditional sprinkler one (27.71 cm). That was the same observation for all fertilizer types. Therefore, regardless of fertilizer type, bottle drip watering provided the best plant growth.

Furthermore, on day 35, comparison of plant height for drip watered plants indicated that it varied following the fertilizer types. Higher plants (47.64 cm) were obtained with organic fertilizer (Agribionate), mean plants (39.66 cm) with chemical fertilizer (NPK) while the control treatment (without fertilizer) provided the smallest plants (7.08 cm). Overall, in the cucumber *poinsett* variety, the best plant growth is achieved on soil supplemented with Agribionate and watered with the bottle drip method.

Analyses of the other growth parameters showed that both fertilizers (Agribionate and NPK) improved respectively leaf number (18.51 and 16.16 *versus* 4.50) per plant, leaf length (11.77 and 11.74 cm *versus* 3.80 cm), spread (14.24 and 14.24 cm *versus* 4.91 cm) and surface (114.62 and 114.42 cm<sup>2</sup> *versus* 14.67), and stem diameter (1.39 and 1.29 cm *versus* 0.58 cm) contrarily to the control treatment (without fertilizer). In sum, fertilization of cucumber plant with organic fertilizer (Agribionate) and watering by drip bottle enhanced growth through their height, leaf number, leaf length, spread and surface and stem diameter.

#### ***Effect on plant yield***

After harvest, values of cucumber yield and yield parameters following plant fertilizer types combined to watering methods are mentioned in Table 6. Regarding plants fertilized with NPK, changing watering mode from traditional sprinkler to bottle drip improved fruits number per plant (from 1.65 to 1.95), fruits size in diameter (from 3.84 to 4.94 cm) in length (from 14.89 to 18.77 cm), and in weight (from 133.43 to 159.41 g) which lead to yield increase (from 5875.83 to 7360.93 Kg/ ha). That is the case for both Agribionate fertilized plants and the control ones (that received no fertilizer). Regardless of fertilizer type (NPK, Agribionate and control), drip bottle watering improved cucumber yield and yield parameters. For all the plants watered by best method (bottle drip), comparison of fertilizer type showed that, the best yield (8941.93 Kg/ ha) and highest fruit number (2.5 fruits per plant) were provided by Agribionate substrate contrarily to the control plants those provided the lowest yield (1583.89 Kg/ ha) and the smallest fruit number (0.95 fruits per plant). Globally, in cucumber, the best yield and yield performance are obtained with plants grown on soil substrate fertilized by Agribionate and watered by bottle drip method.

**Table 1:** Evolution of cucumber plants growing parameters following fertilizer types over the time.

Fertiliser types	Time	Plant growing parameters						
		Plant height	Number of leaves/ Plant	Leaf length (cm)	Leaf spread (cm)	Leaf surface (cm <sup>2</sup> )	Stem diameter at collar (cm)	Bloom number/ plant
NPK	15 DAS <sup>1</sup>	6.08 ± 0.15 <sup>e</sup>	4.75 ± 0.07 <sup>g</sup>	5.57 ± 0.20 <sup>d</sup>	6.66 ± 0.27 <sup>d</sup>	27.77 ± 1.96 <sup>e</sup>	0.60 ± 0.01 <sup>cd</sup>	10.15 ± 0.63 <sup>c</sup>
	25 DAS	11.41 ± 0.52 <sup>d</sup>	6.77 ± 0.19 <sup>e</sup>	8.97 ± 0.25 <sup>b</sup>	10.68 ± 0.31 <sup>c</sup>	68.77 ± 3.49 <sup>d</sup>	1.08 ± 0.13 <sup>b</sup>	15.42 ± 0.89 <sup>b</sup>
	35 DAS	34.21 ± 1.34 <sup>b</sup>	13.71 ± 0.54 <sup>b</sup>	11.11 ± 0.17 <sup>a</sup>	13.35 ± 0.27 <sup>a</sup>	102.58 ± 3.57 <sup>b</sup>	1.27 ± 0.01 <sup>a</sup>	16.36 ± 0.69 <sup>b</sup>
Agribionate	15 DAS	6.59 ± 0.16 <sup>e</sup>	5.15 ± 0.06 <sup>g</sup>	6.16 ± 0.16 <sup>c</sup>	7.24 ± 0.21 <sup>d</sup>	32.42 ± 1.63 <sup>e</sup>	0.65 ± 0.01 <sup>c</sup>	10.00 ± 0.54 <sup>c</sup>
	25 DAS	13.53 ± 0.60 <sup>c</sup>	7.63 ± 0.15 <sup>c</sup>	9.43 ± 0.19 <sup>b</sup>	11.43 ± 0.25 <sup>b</sup>	75.94 ± 2.83 <sup>c</sup>	1.05 ± 0.02 <sup>b</sup>	14.95 ± 0.60 <sup>b</sup>
	35 DAS	37.32 ± 1.60 <sup>a</sup>	15.34 ± 0.51 <sup>a</sup>	11.44 ± 0.15 <sup>a</sup>	13.93 ± 0.22 <sup>a</sup>	109.65 ± 2.99 <sup>a</sup>	1.32 ± 0.01 <sup>a</sup>	19.60 ± 0.64 <sup>a</sup>
Control	15 DAS	2.60 ± 0.17 <sup>f</sup>	3.54 ± 0.16 <sup>h</sup>	2.23 ± 0.14 <sup>f</sup>	2.87 ± 0.20 <sup>f</sup>	5.12 ± 0.76 <sup>f</sup>	0.35 ± 0.01 <sup>e</sup>	2.12 ± 0.30 <sup>d</sup>
	25 DAS	4.93 ± 0.24 <sup>e</sup>	4.21 ± 0.20 <sup>h</sup>	2.86 ± 0.20 <sup>f</sup>	3.83 ± 0.26 <sup>e</sup>	8.95 ± 1.39 <sup>f</sup>	0.49 ± 0.02 <sup>d</sup>	2.63 ± 0.33 <sup>d</sup>
	35 DAS	6.67 ± 0.30 <sup>e</sup>	5.17 ± 0.23 <sup>g</sup>	3.58 ± 0.21 <sup>e</sup>	4.50 ± 0.29 <sup>e</sup>	12.64 ± 1.73 <sup>f</sup>	0.64 ± 0.03 <sup>cd</sup>	0.98 ± 0.14 <sup>d</sup>
Statistics <sup>2</sup>	<i>F</i>	59.29	63.08	316.03	253.64	167.63	60.01	214.78
	<i>P</i>	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

<sup>1</sup>DAS: days after sowing<sup>2</sup>In each column, values with the same superscript letter are not significantly different from each other (ANOVA, P > 0.05)

**Table 2:** Variation of cucumber yield parameters following fertilizer types.

Parameters	Fertiliser types			Statistics*	
	Agribionate	NPK	Control	F	P
Fruits number/ plant	2.65 ± 0.11 <sup>a</sup>	2.22 ± 0.10 <sup>b</sup>	0.87 ± 0.10 <sup>c</sup>	51.77	< 0.001
Fruit weight (g)	138.89 ± 4.50 <sup>a</sup>	149.25 ± 5.41 <sup>a</sup>	60.08 ± 6.93 <sup>b</sup>	60.60	< 0.001
Fruit diameter (cm)	4.28 ± 0.08 <sup>a</sup>	4.11 ± 0.08 <sup>a</sup>	2.84 ± 0.16 <sup>b</sup>	25.23	< 0.001
Fruit length (cm)	14.43 ± 0.16 <sup>a</sup>	16.19 ± 1.82 <sup>a</sup>	8.95 ± 0.94 <sup>b</sup>	7.53	< 0.001
Fruit yield (Kg/ha)	7498,66 ± 809,07 <sup>a</sup>	6600,46 ± 1065,47 <sup>a</sup>	1558,00 ± 185,25 <sup>b</sup>	16,86	< 0.001

\*In each row, values with the same superscript letter are not significantly different from each other (ANOVA, P > 0.05)

**Table 3:** Evolution of cucumber plants growing parameters following watering method over the time.

Watering methods	Time	Plant growing parameters						
		Plant height	Number of leafs/ Plant	Leaf length (cm)	Leaf spread (cm)	Leaf surface (cm <sup>2</sup> )	Stem diameter at collar (cm)	Bloom number/ plant
Bottle drip	15 DAS <sup>1</sup>	6.25 ± 0.20 <sup>e</sup>	4.84 ± 0.08 <sup>e</sup>	5.69 ± 0.20 <sup>e</sup>	6.81 ± 0.24 <sup>e</sup>	29.92 ± 1.74 <sup>e</sup>	0.60 ± 0.01 <sup>d</sup>	8.94 ± 0.54 <sup>c</sup>
	25 DAS	13.35 ± 0.61 <sup>c</sup>	7.18 ± 0.20 <sup>c</sup>	8.62 ± 0.29 <sup>c</sup>	10.35 ± 0.34 <sup>c</sup>	68.38 ± 3.40 <sup>c</sup>	1.08 ± 0.09 <sup>b</sup>	12.48 ± 0.66 <sup>b</sup>
	35 DAS	36.43 ± 1.70 <sup>a</sup>	14.79 ± 0.62 <sup>a</sup>	10.13 ± 0.31 <sup>a</sup>	12.26 ± 0.38 <sup>a</sup>	94.12 ± 4.29 <sup>a</sup>	1.19 ± 0.03 <sup>a</sup>	14.47 ± 0.73 <sup>a</sup>
Traditional sprinkler	15 DAS	4.83 ± 0.15 <sup>e</sup>	4.49 ± 0.09 <sup>e</sup>	4.52 ± 0.19 <sup>f</sup>	5.37 ± 0.24 <sup>f</sup>	19.68 ± 1.48 <sup>f</sup>	0.53 ± 0.01 <sup>d</sup>	7.88 ± 0.55 <sup>c</sup>
	25 DAS	8.34 ± 0.27 <sup>d</sup>	5.98 ± 0.13 <sup>d</sup>	7.15 ± 0.28 <sup>d</sup>	8.77 ± 0.35 <sup>d</sup>	49.83 ± 3.16 <sup>d</sup>	0.79 ± 0.02 <sup>c</sup>	12.77 ± 0.83 <sup>b</sup>
	35 DAS	22.29 ± 1.05 <sup>d</sup>	10.18 ± 0.29 <sup>b</sup>	9.21 ± 0.31 <sup>b</sup>	11.23 ± 0.40 <sup>b</sup>	79.16 ± 4.13 <sup>b</sup>	1.14 ± 0.02 <sup>ab</sup>	14.78 ± 0.93 <sup>a</sup>
Statistics <sup>2</sup>	F	81.05	28.08	14.9	17.66	25.32	4.79	3.95
	P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.008	0.006

<sup>1</sup>DAS: days after sowing

<sup>2</sup>In each column, values with the same superscript letter are not significantly different from each other (ANOVA, P > 0.05).

**Table 4:** Variation of cucumber yield parameters following watering methods.

Yield parameters	Watering methods		Statistics	
	Bottle drip	Traditional sprinkler	t	P*
Fruits number/ plant	2,23 ± 0,10 <sup>a</sup>	2,01 ± 0,12 <sup>a</sup>	1,76	0,185
Fruit weight (g)	132,64 ± 5,56 <sup>a</sup>	118,73 ± 5,61 <sup>a</sup>	3,06	0,08
Fruit diameter	4,06 ± 0,11 <sup>a</sup>	3,75 ± 0,13 <sup>a</sup>	3,21	0,07
Fruit length	14,72 ± 1,27 <sup>a</sup>	13,00 ± 0,41 <sup>a</sup>	1,47	0,22
Fruit yield (Kg/ha)	5895,55 ± 1210,92 <sup>a</sup>	4589,33 ± 940,33 <sup>a</sup>	0,72	0,40

\*In each row, values with the same superscript letter are not significantly different from each other (ANOVA, P > 0.05)

**Table 5:** Evolution of cucumber plants growing parameters following fertilizer types and watering methods over the time.

Fertilizer type	Watering methods	Time	Plant growing parameters						
			Plant height	Number of leaves/ Plant	Leaf length (cm)	Leaf spread (cm)	Leaf surface (cm <sup>2</sup> )	Stem diameter at collar (cm)	Bloom number/ plant
NPK	Bottle drip	15 DAS <sup>1</sup>	6.63 ± 0.21 <sup>gh</sup>	4.82 ± 0.09 <sup>hij</sup>	6.39 ± 0.28 <sup>f</sup>	7.80 ± 0.37 <sup>e</sup>	36.07 ± 2.86 <sup>f</sup>	0.60 ± 0.02 <sup>fg</sup>	11.90 ± 0.89 <sup>e</sup>
		25 DAS	13.47 ± 0.81 <sup>e</sup>	7.40 ± 0.30 <sup>e</sup>	10.03 ± 0.34 <sup>c</sup>	11.93 ± 0.41 <sup>b</sup>	84.41 ± 4.81 <sup>c</sup>	1.29 ± 0.23 <sup>ab</sup>	14.32 ± 0.98 <sup>d</sup>
		35 DAS	39.66 ± 1.84 <sup>b</sup>	16.16 ± 0.82 <sup>b</sup>	11.77 ± 0.25 <sup>a</sup>	14.05 ± 0.37 <sup>a</sup>	114.42 ± 5.17 <sup>a</sup>	1.29 ± 0.01 <sup>ab</sup>	15.58 ± 0.67 <sup>cd</sup>
	Traditional sprinkler	15 DAS	5.42 ± 0.18 <sup>i</sup>	4.67 ± 0.11 <sup>ij</sup>	4.60 ± 0.21 <sup>h</sup>	5.30 ± 0.29 <sup>g</sup>	17.89 ± 1.65 <sup>g</sup>	0.59 ± 0.02 <sup>fg</sup>	8.07 ± 0.76 <sup>g</sup>
		25 DAS	8.97 ± 0.37 <sup>fg</sup>	6.02 ± 0.13 <sup>fg</sup>	7.72 ± 0.27 <sup>e</sup>	9.19 ± 0.33 <sup>d</sup>	50.15 ± 3.27 <sup>e</sup>	0.84 ± 0.03 <sup>cd</sup>	16.74 ± 1.55 <sup>cd</sup>
		35 DAS	27.71 ± 1.42 <sup>c</sup>	10.79 ± 0.26 <sup>c</sup>	10.31 ± 0.17 <sup>c</sup>	12.50 ± 0.36 <sup>b</sup>	88.50 ± 3.89 <sup>c</sup>	1.25 ± 0.01 <sup>ab</sup>	17.29 ± 1.28 <sup>bc</sup>

Agribionate	Bottle drip	15	7.59	5.32	6.63 ±	7.70	35.90	0.71	9.40
		DAS	±0.19 <sup>fgh</sup>	±0.08 <sup>ghi</sup>	0.19 <sup>f</sup>	±0.22 <sup>e</sup>	±2.13 <sup>f</sup>	±0.01 <sup>fg</sup>	±0.74 <sup>fg</sup>
		25	17.14 ±	8.49	10.04	11.90	82.17	1.19	15.37
	DAS	0.87 <sup>d</sup>	±0.19 <sup>d</sup>	±0.19 <sup>c</sup>	±0.29 <sup>b</sup>	±3.32 <sup>c</sup>	±0.02 <sup>b</sup>	±0.85 <sup>cd</sup>	
	35	47.64 ±	18.51	11.74	14.24	114.62	1.39	19.85	
	DAS	2.00 <sup>a</sup>	±0.67 <sup>a</sup>	±0.19 <sup>a</sup>	±0.28 <sup>a</sup>	±3.83 <sup>a</sup>	±0.01 <sup>a</sup>	±0.77 <sup>ab</sup>	
	Traditional sprinkler	15	5.45 ±	4.96	5.63	6.72	28.39	0.57	10.69
		DAS	0.13 <sup>i</sup>	±0.07 <sup>hij</sup>	±0.25 <sup>g</sup>	±0.36 <sup>f</sup>	±2.40 <sup>f</sup>	±0.01 <sup>fg</sup>	±0.79 <sup>ef</sup>
		25	9.50 ±	6.66	8.76	10.92	69.01	0.89	14.47
DAS		0.32 <sup>f</sup>	±0.15 <sup>ef</sup>	±0.31 <sup>d</sup>	±0.42 <sup>c</sup>	±4.54 <sup>d</sup>	±0.03 <sup>c</sup>	±0.85 <sup>d</sup>	
35		25.39 ±	11.67	11.08	13.57	103.89	1.25	19.31	
DAS		1.18 <sup>c</sup>	±0.38 <sup>c</sup>	±0.24 <sup>b</sup>	±0.33 <sup>a</sup>	±4.60 <sup>b</sup>	±0.01 <sup>ab</sup>	±1.07 <sup>ab</sup>	
Control	Bottle drip	15	2.72 ±	3.86	2.43	3.13	6.12	0.36	2.68
		DAS	0.25 <sup>i</sup>	±0.22 <sup>jk</sup>	±0.22 <sup>jk</sup>	±0.29 <sup>j</sup>	±1.21 <sup>h</sup>	±0.01 <sup>h</sup>	±0.49 <sup>h</sup>
		25	5.14 ±	4.04	3.09	4.27	10.68	0.48	3.11
	DAS	0.32 <sup>i</sup>	±0.21 <sup>jk</sup>	±0.31 <sup>ij</sup>	±0.38 <sup>ghi</sup>	±2.14 <sup>gh</sup>	±0.02 <sup>gh</sup>	±0.55 <sup>h</sup>	
	35	7.08 ±	4.50	3.80	4.91	14.67	0.58	1.18	
	DAS	0.43 <sup>gh</sup>	±0.20 <sup>ij</sup>	±0.32 <sup>hi</sup>	±0.44 <sup>gh</sup>	±2.65 <sup>gh</sup>	±0.04 <sup>fg</sup>	±0.21 <sup>h</sup>	
	Traditional sprinkler	15	2.47 ±	3.17	1.99	2.58	3.96	0.35	1.46
		DAS	0.23 <sup>i</sup>	±0.21 <sup>k</sup>	±0.14 <sup>k</sup>	±0.25 <sup>j</sup>	±0.83 <sup>h</sup>	±0.01 <sup>h</sup>	±0.27 <sup>h</sup>
		25	4.69 ±	4.42	2.60	3.32	6.93	0.49	2.08
DAS		0.38 <sup>i</sup>	±0.35 <sup>ijk</sup>	±0.24 <sup>jk</sup>	±0.33 <sup>ij</sup>	±1.62 <sup>gh</sup>	±0.03 <sup>gh</sup>	±0.30 <sup>h</sup>	
35		6.20 ±	5.96	3.31	4.03	10.27	0.70	0.75	
DAS		0.42 <sup>j</sup>	±0.38 <sup>fgh</sup>	±0.26 <sup>ij</sup>	±0.36 <sup>hi</sup>	±2.06 <sup>gh</sup>	±0.03 <sup>fg</sup>	±0.16 <sup>h</sup>	
Statistics <sup>2</sup>	<i>F</i>	72.05	37.06	21.93	19.66	18.23	14.97	18.90	
	<i>P</i>	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	

<sup>1</sup>DAS: days after sowing;

<sup>2</sup>In each column, values with the same superscript letter are not significantly different from each other (ANOVA, P > 0.05).

**Table 6.** Variation of cucumber yield parameters following fertilizer types and watering methods.

Fertiliser types	Watering methods	Yield parameters				
		Fruits number/ plant	Fruit weight (g)	Fruit diameter (cm)	Fruit lenght (cm)	Fruit yield (Kg/ha)
Control	Bottle drip	0.95 ± 0.11 <sup>e</sup>	91.86 ± 10.96 <sup>c</sup>	2.81 ± 0.21 <sup>d</sup>	10.24 ± 1.28 <sup>d</sup>	1583.89 ± 196.11 <sup>c</sup>
	Traditional sprinkler	0.70 ± 0.09 <sup>d</sup>	75.97 ± 5.28 <sup>c</sup>	2.32 ± 0.13 <sup>d</sup>	8.47 ± 0.87 <sup>e</sup>	1561.74 ± 264.46 <sup>c</sup>
NPK	Bottle drip	1.95 ± 0.18 <sup>c</sup>	159.41 ± 13.29 <sup>a</sup>	4.94 ± 0.15 <sup>a</sup>	18.77 ± 0.99 <sup>a</sup>	7360.93 ± 935.17 <sup>ab</sup>
	Traditional sprinkler	1.65 ± 0.15 <sup>d</sup>	133.43 ± 6.23 <sup>b</sup>	3.84 ± 0.18 <sup>c</sup>	14.89 ± 1.05 <sup>c</sup>	5875.83 ± 536.52 <sup>b</sup>
Agribionate	Bottle drip	2.50 ± 0.17 <sup>a</sup>	145.10 ± 6.37 <sup>a</sup>	4.27 ± 0.09 <sup>ab</sup>	16.18 ± 1.06 <sup>b</sup>	8941.93 ± 708.85 <sup>a</sup>
	Traditional sprinkler	2.16 ± 0.13 <sup>b</sup>	131.18 ± 6.70 <sup>b</sup>	4.01 ± 0.07 <sup>bc</sup>	14.62 ± 1.23 <sup>c</sup>	7042.93 ± 821.52 <sup>ab</sup>
	<i>F</i>	63.05	27.32	16.39	18.65	15.26
Statistics	<i>P</i> *	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

\*In each column, values with the same superscript letter are not significantly different from each other (ANOVA, P > 0.05).

## DISCUSSION

The production of any crop depends not only on the quality of sown seeds, but also on its technical itinerary, including the fertilizer type and watering method (Abdelaziz and Abdeldaym, 2018). Our study showed that globally fertilizer type (Agribionate, NPK and control) and the watering method (traditional sprinkler and bottle drip), individually or combined, influenced significantly the plants growth and yield of the cucumber Poinsett variety.

During their cycle, cucumber plants fertilized with organic (Agribionate) and mineral (NPK) fertilizers showed the strongest growth with the longest main stem, the greatest number of leaves, more flowers produced leading to the highest yields, unlike the controls (without fertilizer) which produced the lowest performances. These good agronomic performances of the cucumber plants, fertilized with Agribionate and NPK, could be attributed to a high level of available nutrients they contain. Similar observations were made by Cîmpeanu et al. (2013) in cucumbers. Indeed, they showed that the application of organic fertilizers, organic or mineral complex allowed growth and fruiting in this species. Moreover, in another study on cucumbers, Abdelaziz and Abdeldaym (2018) observed that yield at harvest depends on the plants' performance during growth. It is undoubtedly the reason why cucumber plants fertilized with both fertilizer types (NPK and Agribionate) developed longer stems than those of control plants (without fertilizer). Further, the low vigor of the control (non-fertilized) plants could be explained by the poor nutrient content of their natural substrate. Similar observations have already been reported by Moké et al. (2013) and Namoi et al. (2014).

Watering methods (traditional sprinkler and bottle drip) also influenced differently cucumber plant performances. Indeed, the best performances expressed through the main stem length, the number of leaves and flowers, were obtained with bottle drip watering compared to traditional sprinkler. This result could be attributable to the always water availability, with less loss, at the plants' roots during their

crop cycle. On cons with the traditional sprinkler watering, although plants are supplied with equal water quantities, significant losses due to evaporation could have caused water deficits to the plants when they need it the most. Adeogun (2017) has already reported similar observation in cucumbers. Our results also confirm those of Nowakowski et al. (2019) who found that the use of drip watering improved vegetation and yield of strawberry more than the motorized sprinkler technique using a motor pump.

At harvest, cucumber fruit production was influenced by the nature of the sowing substrate. In fact, cucumber plants feed by the mineral (NPK) and organic (Agribionate) fertilizers provided the best agronomic performance through weight, size (length and diameter) and fruit yield. According to Abdelaziz and Abdeldaym (2018), the use of fertilizers promotes growth of vegetative organs and contributes to increasing fruit production in cucumbers. In addition, several researchers (Abbasi et al., 2002; Eifediya and Remison, 2010) showed that, despite plant growth stimulation, these fertilizers nitrogen type is essential especially for leaf and stem expansion. They also noted an increase in blossom and fruit production with fertilizer inputs. Although both fertilizers types (Agribionate and NPK) stimulate the growth and development of the cucumber plants studied, their effect did not show the same intensity. Indeed, the organic fertilizer (Agribionate) was more effective in stimulating growth and development than the mineral one (NPK). Organic fertilizers are recognized as an effective resource for soil fertility maintenance and/or restoration by providing a wide range of macro- and micro-nutrients (Pulgar et al., 2000). Moreover, a similar observation had previously already been reported by Cîmpeanu et al. (2013) in cucumbers and by Anguessin et al (2021) in tomatoes. According to them, in addition to its richness in mineral nutrients, organic manure is also characterized by its capacity to improve the physical and microbiological properties that favors roots development and their better penetration into the soil in search of nutrients.

Furthermore, the mineral nutrients adsorption by the present clay-humus complexes and their release when the plant needs them (Kamal et al., 2012; Mukendi et al, 2017) could explain the best performance of Agribionate organic fertilizer.

Combination of fertilizer type to watering method affected the growth and yield of the studied cucumber Poinsett variety. The best performances were obtained with plants fertilized with organic fertilizer (Agribionate) and watered by bottle drip way. This result could be explained by the richness of these fertilizer mineral nutrients, its capacity to improve the physical and microbiological properties and, their good availability favored by the presence of water thanks to the drip watering method. As a matter in fact, even when present, the minerals must be solubilized by the soil water and adsorbed by the colloids in order to be released for absorption by the plant (Kamal et al., 2012; Adeogun, 2017). As a result, the successful growth of plants fertilized with Agribionate and drip-watered favored the best flowering and then fruiting, which explains the higher yield. Mukendi et al, (2017) obtained similar results in maize culture.

### Conclusion

Cucumber fertilization enhanced plant growth in height and stem diameter, leaf emission and expansion which also favored flowering leading to better yield in fruits production, especially with organic fertilizer (Agribionate) followed by chemical one (NPK). Watering methods also affected these performances, bottle drip being better than traditional sprinkler. Combined effect of both analyzed factors (fertilizers type and watering methods) indicated that in cucumber Poinsett variety, the best plant growth leading to fruit highest yield could be obtained through organic fertilization (Agribionate) and bottle drip watering method.

### COMPETING INTERESTS

We declare that we have no competing interests.

### AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. Author KBY designed the study, and wrote the protocol and the first manuscript draft and performed the statistical analysis. Author KKL collected data and with KA, both managed the analyses of the study. Author THK managed the literature searches. All authors read and approved the final manuscript

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