Asian Research Journal of Agriculture

Volume 16, Issue 1, Page 17-30, 2023; Article no.ARJA.97403
ISSN: 2456-561X

Evaluation of Seven Phenoxyacetic Acid Drifts on Morphological Parameters of Three Rice (*Oryza sativa* L.) Varieties under Controlled Sowing Conditions in Côte d'Ivoire

Francis Koffi Bédié [a*], Didier Konan Kouamé [a], Aboudramane Koné [b], Victor Tiéba Ouattara [c] and Louise Turquin [a]

[a] Laboratory of Biotechnology, Agriculture and Valorization of Biological Resources, Pedagogical and Research Unit of Plant Physiology and Pathology, UFR Biosciences, University Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire.
[b] Laboratory of Environmental Sciences and Technology, UFR Environment, Université Jean Lorougnon Guédé, Daloa, Côte d'Ivoire.
[c] Laboratory of Plant Physiology, University Jean Guédé Lorougnon, Daloa, Côte d'Ivoire.

Authors' contributions

This work was carried out in collaboration between all the authors. The other author FKB, LT and DKK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. The author AK was the one who synthesized the phenoxyacetic acid derivatives used in this study. Author VTO provided substantial financial support for the set-up of the trial and the collection of data. All authors have read and approved the final manuscript.

Article Information

DOI: 10.9734/ARJA/2023/v16i1379

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/97403

Original Research Article

Received: 14/01/2023
Accepted: 18/03/2023
Published: 23/03/2023

**Corresponding author: E-mail: bediekoffi2012@yahoo.fr;*

ABSTRACT

Rice, the main food of the population in Côte d'Ivoire, has a low yield. This study aimed to evaluate the ability of phenoxyacetic acid derivatives to boost the vegetative parameters of rice was conducted in Azaguié using a split-plot design. The rice varieties WA638-1, C26, Nérica 2 and seven phenoxyacetic acid derivatives were used. Three rice seeds of each variety were sown in pots. One seedling per variety was de-mated at 7 DAS. Volumes of 150, 180, and 225 ml concentrated at 10^{-5} M, 10^{-7} M, and 10^{-9} M were applied to the leaves on 15, 20, and 25 DAS, respectively. Height, number of tillers, girth and vigor index were determined. The results showed that treatment T7 improved the height of WAB638-1 to 6.75% and tillering to 366.6%. The vigor index was increased to 9.52% by T8 treatment and girth to 80.37% by T20. The formation of C26 tillers was favored at 171% by the T7 treatment, the girth at 83.17% by T21, the vigor index at 10 % by T21 and at 7.50% by the T14 and T8 treatments. In Nérica 2, vigor index and girth were positively induced at 15.15% and 34.83 % by T19 respectively. The vigor index was also promoted at 12.12% by treatments T20 and T21 and the number of tillers was improved at 150% by T13 and T19. As for height, it was stimulated to 22.39 % by the T14 treatment. The height of C26 was reduced except for T12, the vigor index was decreased to 2.50% by treatments T15, T17 and T3, the tillering to 66.70% by T4. The height of WAB638-1 was inhibited to 2.56% with T1 treatments. Treatments T13, T14, T7, T8, T19 and T20 were those that improved the observed parameters.

Keywords: Rice; Oryza sativa L; growth regulators; auxin derivatives; Côte d'Ivoire.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the main crops and is consumed by nearly 2.5 billion people worldwide. It is cultivated in many developing countries and is the primary source of income, jobs and calories for more than 100 million households in Africa and Asia [1]. In sub-Saharan Africa, especially in Côte d'Ivoire, rice is consumed in most households at least once a day and replaces traditional staple foods [2]. Rice is the third most important food crop after yam and cassava and contributes about 17% of total agricultural employability. It ranks third after cocoa and vegetable growing and contributes 9.9% to Ivorian GDP [3]. The improvement of its grain yield is traditionally done by inputs of fertilizers such as organic matter (manure, manure, manure...), green fertilizers (legumes fixing atmospheric nitrogen) and NPK chemical fertilizers implemented by agronomic research [4]. Despite these inputs, the average yield of rice production, and especially rainy rice production in rural areas, is still low (1.24 t/ha) [5]. This poor rice production can be partially attributed in part to inadequate nutrition of growing rice plants, especially in the reproductive stage, where nutrient demand is higher [6]. Efficient mineral absorption would lead to rice plant vigour and allow rice varieties to express their grain yield potential. This could be accomplished effectively by using plant plant growth controls [2]. These regulators, which are organic compounds, other than nutrients, modify the physiological processes of plants and are [7]. They act within plant cells and play an important role in crop growth, yield and quality [8]. In addition, they regulate the type and sense of plant growth and enable improve plant development and yield in multiple crops [9]. For example, auxin regulates cell elongation, tissue swelling, plant growth, root formation and increased yield enhancement [10]. Similarly, gibberellic acid is involved in the regulation of many growth and development processes of various plants, including rice [11,12]. The application of plant growth regulators enhance photosynthesis capacity, delays leaf senescence and increases rice grain production [13]. Naphthalen acetic acid been shown to optimize the grain yield potential of rice [14,15]. Currently in Côte d'Ivoire, growth regulators are used in in vitro culture. In hydroponic culture, phenoxyacetic acid derivatives have been used to promote the budding of banana scale discharges that have been transferred to the high yield [16]. However, for rice there is limited information about the use of phenoxyacetic acid derivatives. The aim of this study was to evaluate the capacity of other derivatives to stmulate the morphological parameters of three rice varieties.

2. MATERIALS AND METHODS

2.1 Experimental Site

The test was performed at Abbe junction of geographic coordinates 5°37'39'' North and

4°01'31'' West. Abbe is part of the commune of Azaguie which is in the south of Côte d'Ivoire, 40 km north of Abidjan, between 5°38' and 5°00' North and 4°05' and 4°00' West [17]. Attica's climate is characterized by two rainy seasons (average rainfall of 1400 mm) and two dry seasons. The major rainy season runs from May to mid-July and the short one from mid-September to October. The long dry season starts in November and ends in April; the short dry season between mid-July and mid-September [18]. Precipitation is heavy with a mean annual temperature of 28°C [1]. The vegetation is set aside and the soil is sandy and fairly uniform in texture. Soil pH is acidic (5.5) with a low organic matter content (1.44%). Its physical-chemical composition varies depending on the explation horizon. The C/D ratio is therefore 52.5 for the 0-20 cm horizon and 67.6 for 20-40 cm. The total phosphorus content varies from 214.75 to 229.08 mg.kg-1, the assimilate phosphorus content is estimated at 53 ppm, carbon varies from 5.78 to 3.38 g.kg-1 and nitrogen from 0.11 to 0.05 g.kg-1 [1].

2.2 Material

The plant material consisted of three rice varieties developed by AfricaRice. The variety WAB638-1 massal selection from a local aromatic population, can be grown both in rainfall and irrigated conditions. It has a long cycle of 135 days and a vegetative phase of 60 days. At maturity, this variety has an average height of 135 cm, a yield between 4.5 and 6 t/ha with a mass of 1000 grains of 24.1 g [19].

NERICA results from an interspecific cross between Oryza sativa (L.) high-yielding Asian rice variety and Oryza glaberrima (Steud), an African rice variety that is more resistant to biotic stress [20]. NERICA 2 originated from the cross between WAB56-104/CG 14//2 and WAB56-104. It is grown in rainfall with an average cycle of 95-100 days. The vegetative period is 30 to 45 days. Its yield is 4 t/ha with a mass of 1000 grains of 26 g, an average height at maturity of 105 cm.

The pure line variety C26 is drought tolerant. It is grown under irrigation and in the shallows. It is a medium cycle variety of 102 days. It has an average height at maturity of 102 cm, its yield is 4.5 to 6 t/ha and a mass of 1000 grains equal to 22.25 g [21,22].

WAB638-1 was chosen because it is highly prized by populations for its taste; NERICA 2 and C26 for their early appearance.

2.3 Chemical Material

The auxin compounds derived from phenoxyacetic acid used, were synthesized by the Organic Chemistry Laboratory according to the method of Pokorny cited by (Zimdahl, 2010). They include four groups (Table 1).

2.4 Methods

2.4.1 Experimental design

The experimental setup was a randomized split-plot with 3 replicates (Fig. 1). Seven derivatives (ACPA, 2,4-DCPAA, 2,5-DMPAA, ACMA; ACPP, ACPP, ACPP and ACMPP) were each evaluated at three concentrations (10^{-5} M, 10^{-7} M and 10^{-9} M). Thus, 22 treatments (7 x 3 + 1 control) (Table 2) were applied to the three varieties (WAB638-1, C26 and NERICA 2). The experimental units (lot I) consisted of 135 plants in bags of size 28 cm x 20 cm filled with soil from the 0-20 cm sterilized horizon. They were spaced 0.5 m apart and subdivided into three sublots (lot II) of 45 plants. The latter were also made up of three batches (batch III) of 15 plants spaced 0.5 m apart representing a variety for the controls, a hormone with a concentration associated with each variety and constituted the treatments. The total area of the experiment was 177.30 m2 (27.30 m x 6.5 m).

Table 1. Phenoxyacetic acid derivatives and chemical formulas

Phenoxyacetic acid derivatives	Chemical formulas
Phenoxyacetic acid (ACPA)	$C_6H_5COCH_2CO_2H$
2.4-dichlorophenoxyacetic acid (2.4-DCPAA)	$2ClC_6H_3COCH_2CO_2H$
2.5-dimethylphenoxyacetic acid (2,5-DMPAA)	$C_2H_6C_6H_3COCH_2CO_2H$
Methylphenoxyacetic acid (ACMA)	$CH_3C_6H_5COCH_2CO_2H$
Phenoxypropanoic acid (PPPA)	$C_6H_5COCH_2CH_2CO_2H$
2.4-dimethylphenoxypropanoic acid (2.4-DMPPA);	$C_2H_6C_6H_3COCH_2CH_2CO_2H$
Methylphenoxypropanoic acid (ACMPP).	$CH_3C_6H_4COCH_2CH_2CO_2H$

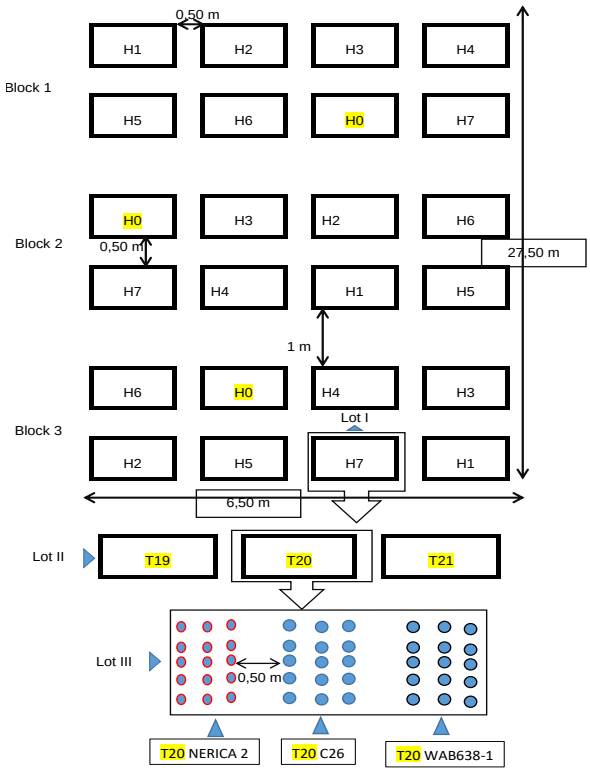

Fig. 1. Experimental setup

H1: 2.5-DMPAA (2.5-dimethylphenoxyacetic acid), H2 : 2.4-DCPAA (2.4-dichlorophenoxyacetic acid), H3 : 2.4-DMPPA (2.4-dimethylphenoxypropanoic acid), H4 : ACPA (phenoxyacetic acid), H5 : PPPA, (phenoxypropanoic acid) H6 : ACMA (methylphenoxyacetic acid), H7 : ACMPP (methylphenoxypropanoic acid), T20: ACMPP 10^{-7} M

Table 2. Derivatives concentration (M) and treatments

Derivatives	Concentration (M)	Treatments
H0 (water)	0	T0
	10^{-5}	T1
2,5-DMPAA (H3)	10^{-7}	T2
	10^{-9}	T3
	10^{-5}	T4
2,4-DCPAA (H2)	10^{-7}	T5
	10^{-9}	T6
	10^{-5}	T7
2,4-DMPPA (H6)	10^{-7}	H8
	10^{-9}	H9
	10^{-5}	T10
ACPA (H1)	10^{-7}	T11
	10^{-9}	T12
	10^{-5}	T13
PPPA (H5)	10^{-7}	14
	10^{-9}	T15
	10^{-5}	T16
ACMA (H4)	10^{-7}	T17
	10^{-9}	T18
ACMPP (H7)	10^{-5}	T19
	10^{-7}	T20
	10^{-9}	T21

2.4.2 Conduct of the trial

Sowing: the trial was conducted under controlled sowing conditions in 28 cm x 22 cm pots filled with sterilized soil (horizon 0-20 cm). The rice grains were soaked in distilled water for 24 h to eliminate floating grains and stimulate germination. Direct seeding was carried out at a depth of 2-3 cm with three to four grains per plot, and de-sowing at one foot per plot was carried out 7 days later.

Maintenance: dduring the 60 days of the trial, two weedings were done at 21 and 40 days. The plants were watered every 2 days according to the needs of the crop.

Obtaining stock and applied solutions: A 20 ml stock solution at 10-3 M of each auxin analog was prepared 24 h before the first application. For each compound, a mass m (g) was taken. Each mass thus taken was introduced into a small volume of distilled water. To allow complete dissolution of the crystals, a volume of 2 ml of 0.1 N NaOH was added to the acid-distilled water mixture while it was homogenized with the help of a magnetic stirrer. The solutions were put in smoked bottles to prevent light from altering the products, labeled and stored in a refrigerator at 4°C. For each application, the volume to be applied was determined the day before with a 250 ml sprinkler. The average volume was 150 ml, 180 ml and 225 ml per batch of 45 respectively for the 1st, 2nd and 3rd application. To prepare hormone solutions equivalent to these volumes, an aliquot of 1.5 ml (150 ml), 1.8 ml (180 ml) and 2.25 ml (225 ml) of each stock solution was taken. Each was diluted to have solutions of volumes 150 ml, 180 ml and 225 ml each concentrated by 10^{-5} M, 10^{-7} M and 10^{-9} M.

Application of solutions: The solutions of volume 150, 180 and 225 ml each concentrated with 10-5 M, 10-7 M, 10-9 M constituting with the control (water) treatments were applied on the rice leaves of each batch of 45 plants respectively on the 15^{th}, 20^{th} and 25^{th} day on the leaves using the same sprinkler**..**

2.5 Parameters Studied

In this study, growth was assessed by height and girth dimensions; development by plant tillering. Measurements were taken for a given treatment, on a sample of 45 plants representing the number of plants in the three blocks for the treatment. Measurements were made on day 30, day 45th and 60 and day 60th day following planting.

2.6 Height

Height measured with a tape measure from the crown to the tip of the leaves of the main plants was expressed in centimeters (cm) [23].

2.7 Circumference

The circumference of the clumps of rice plants was measured at the collar of the rice plants using a using a tape measure and expressed in cm.

2.8 Number of Tillers

The number of tillers was counted per plant and the average was expressed as tillers/plant [23].

2.9 Vigor Index

The vegetative vigor index (IV) calculated according to the formula of [17] which was modified and adapted to our trial using the circumference C π =D.

$$IV = \log (C^2 \times H/4\pi.)$$

C: circumference (cm), H: height (cm) and π = 3.14

2.10 Rate of Increase

The rate of increase (ROI) indicating the activity of the derivatives on the parameters: height, circumference, vigor index or tillering, was calculated according to the formula in [24].

$$TA (\%) = [(Tn - T0) / T0] \times 100$$

T0: height, girth or tillering of control plants
Tn: height, circumference or tillering of treated plants.

2.11 Statistical Analysis

The collected data were subjected to an analysis of variance (ANOVA) using STATISTICA 7.1 software. The ANOVA was used to compare the effect of phenoxyacetic acid derivatives on the parameters studied. In case of a significant effect of the treatment, the Newman-Keuls test of comparison of means was applied to classify them into homogeneous groups at the 5%

threshold. A principal component analysis (PCA) performed with the LXSTAT software was used to characterize the best derivatives.

3. RESULTS AND DISCUSSION

3.1 Height

Plant height and growth rates relative to the controls of the three varieties presented in Table 3. It shows a difference with the treatments regardless of the variety (P< 0.05). The height of the control plants was 97.58 cm (WAB638-1), 80.33 cm (C26) and 84.40 cm (NERIA 2). The height of the treated plants varied from 94.92 to 103.75 cm (WAB638-1), 57.50 to 83.58 cm (C26) and 84.40 to 103.30 cm (NERICA 2).

The highest height of WAB638-1 was obtained with T17 (104.17 cm) with an increase rate of (6.76%) and T13 (103.75 cm) for an increase rate of 6.36% followed by T14 which recorded a height of 102.42 cm (4.92%). The height was reduced by 2.56% by T1 and those obtained withT2, T3, T4, T6, T9 and T21 were identical to the control. The other treatments were intermediate.

For the C26 variety, the best sizes were recorded with T20 (83.58 cm) and the control (80.33 cm).

Concerning the variety NERICA 2, all the derivatives had a positive effect on this variable.

However, the highest height was observed with T11. It increased this parameter by 22.39% (103.39 cm) and the control plants with the lowest height. The treatments that promoted height stimulated the apical meristems at the leaf apices and activated the intercalary meristems of the internodes via gibberellins. This led to cell elongation. Our results corroborate those of [25] who obtained an improvement in the height of chickpea by spraying indole-3-butyric acid; as well as those of [26] who, treating rice varieties with naphthalene acetic acid obtained higher heights compared to the control.

3.2 Circumference

The circumference of the plants varied from 10.50 to 19.30 cm (WAB638-1); 9.70 to 18.50 cm (C26); 6 to 12 cm (NERICA 2) and 10.70 to 8.90 cm (controls) with a highly significant difference (P<0.05) (Table 4). with WAB638-1, the lowest circumference, was observed with T2. This value which was smaller was not statistically different from the control (10.70 cm). T20 gave the plants the greatest radial growth (19.30 cm or 80.37%). It was followed by T8 (18.10 cm or 69.16%), T19 (16.60 or 55.40%) and T20 (16.20 cm and 51.40%). T19 and T20 not belonging to the same group were statistically different T8. Treatments T1, T3, T3 to T6, T13, T14, T17 and T18 were close to the control.

For the variety C26, T13 whose average was 16.70 cm or 65.35% was preceded by T21 (18.5 cm or 83.17%). T17 had the lowest value (9.70 cm). The effects of treatments T1 to T5, T15, T16, T18 and T20 were close to the control (10.10 cm).

For NERICA 2, T1 to T6, T10, T16 to T18 showed regressive effects ranging from -39.33 to –35.96. Treatments T8, T20, T21, T13, T14, T15, T7, T8, and T9 had a positive effect. Among them, those that improved the most on this parameter were T19 (12 cm or 34.83%), followed by T20 and T13 with an average of 11.40 cm, or an increase of 28.09%. T11, T12 and T21 were statistically similar to the control. The treatments that induced optimal development of the circumference would have caused proliferation of the generative libero-ligneous zone at these concentrations leading to differentiation of the xylem and phloem layers thus causing thickening at the neck of the clumps [27,28,29]. Similar results were obtained with auxin, which increased the stem circumference of okra [30,24]. Vessel diameters of Populus xylem were also improved by growth regulators [31,25]. The inhibitory effect of some treatments on varietal height and girth would be related to specific chemical toxicity. These results are in agreement with those of some authors on peanut and bean. The latter have reported that the toxicity is related to certain analogues and high doses of auxin [32,33,26,27].

3.3 Vigor Index

The average heights and neck girths measured for each treatment and variety were used to calculate vigor indices (Table 5). They showed significant differences between treatments (P<0.05). The results reveal that plants of the variety WAB638-1 treated with T20 and T8 gave the highest vigor indices. For these two treatments, the average value of the vigor index was 4.60 with respective growth rates of 9.52% followed by T19 and T14 (4.5 or 7.14%). T1 and T16 with the average of 4.10 or -2.38% reduced this parameter. This value was t statistically low compared to the control. T2 to T6, T15, T13, T17 and T18 had a statistically equal effect to the control.

Table 3. Effect of auxin derivatives on height

Treatments	WAB638-1		C26		NERICA2	
	Height (cm)	AR (%)	Height (cm)	AR (%)	Height (cm)	AR (%)
T0	97.58 de	-	80.33 a	-	84.40 b	-
T1	95.08e	-2.56	64.50 gh	-19.68	98.00 ab	16..
T2	96.33 de	-1.33	67.08fg	-16.44	95.20 ab	12.80
T3	96.83 de	-0.75	57.50 i	-28.39	94.10 ab	11.49
T4	96.25 de	-1.33	61.58 hi	-23.29	91.00 ab	7.82
T5	96.75de	-0.82	58.42 hi	-27.27	99.00 ab	17.30
T6	96.92 de	-0.66	62.42 hi	-22.29	99.00 ab	17.30
T7	104.17 a	6.76	72.67 b	-9.46	86.30 ab	2.25
T8	98.33 cd	0.72	64.33 gh	-19.93	97.30 ab	15.28
T9	97.58 de	-0.41	65.25 gh	-18.80	100.90ab	19.55
T10	99.92 cd	2.36	66.08 fg	-17.68	92.00 ab	9.00
T11	102.00 bc	4.51	69.08 ef	-13.95	100.10 ab	18.60
T12	101.08cd	3.59	71.98 bc	-10.46	90.10 ab	6.75
T13	103.75 a	6.35	70,25cd	-12.58	93.20 ab	10.43
T14	102.17 bc	4.71	63.83 hi	-20.55	92.60 ab	9.72
T15	96.42 de	-1.14	64.08 hi	-20.17	103.30 a	22.39
T16	98.08cd	0.51	63.31 hi	-21.30	93.30ab	10.55
T17	99.75 cd	2.25	70.71 de	-12.70	88.60 ab	4.98
T18	98.92 cd	1.33	66.70 fg	-16.94	88.10 ab	4.38
T19	99.25cd	1.74	63.17 hi	-21.30	95.50 ab	13.15
T20	102.42 ab	4.92	60.58 hi	-24.53	97.07 ab	15.01
T21	96.92 de	-0.72	83.58 a	4.11	94.40 ab	11.85
Newman Keuls P < 0.05	0.00		0.00		0.00	

Values with different letters in the same column differ at the 5% level of the Newman-Keuls test.
AR: rate of increase relative to the control, T0 : control (water),T1 : 2.5-DMPAA 10^{-5} M, T2 : 2.5-DMPAA 10^{-7} M, T3 : 2.5-DMPAA 10^{-7} M, T4 : 2.4-DCPAA 10^{-5} M, T5 : 2.4-DCPAA 10^{-7} M, T6 : 2.4-DCPAA 10^{-9} M, T7 : 2.4-DMPPA 10^{-5} M, T8: 2.4-DMPPA 10^{-7} M, T9 : 2.4-DMPPA 10^{-9} M, T10 : ACPA 10^{-5} M , T11 : ACPA 10^{-7} M, T12 : ACPA 10^{-7} M, T13 : PPPA 10^{-5} M, T14 : PPPA 10^{-7} M, T15 : PPPA 10^{-9} M, T16 : ACMA 10^{-5} M, T17 : ACMA 10^{-7} M, T18 : ACMA 10^{-9} M, T19 : ACMPP 10^{-5} M , T20 : ACMPP 10^{-7} M and T21 : ACMPP 10^{-9} M

In C26, plants treated with T21 (4.40 or 10%) and T7 (4.30 or 7%) had the highest vigor indices with identical influence. Their effect was followed by those of T11, T8 and T9 with an average of 4.20 (5%). The T17 treatment (9.70 or -3.96%) gave the lowest value. With T1 to T5, T15, T18 and T20 the vigor index was close to the control (10.10).

For NERICA 2, plants sprayed with T16 had the lowest vigor index (2.90 or -12.12). On the other hand, those treated with T19 (3.80 or 15.15%), T20 (3.70 or 12.20%), T21 (3.70 or 12.20%) and T13 (3.80 or 15.15%) recorded the highest vigor indexes with corresponding growth rates. The averages of this variable noted with T9, T17, T18 and from T1 to T6 were not different from the control. The positive influence of on the vigor index, reflects the good accumulation of organic matter in these varieties under these treatments [1]. Indeed, they would have increased the accumulation of some microelements such as nitrogen, magnesium and iron that are involved in the synthesis of chlorophyll, which increased the efficiency of photosynthesis and the manufacture of organic matter. Our results are close to those of studies carried out with a hybrid rice. The results of this study showed an improvement in the vigor index of the stigmas of this plant after treatment with gibberellin [34,28].

3.4 Number of Stubs

The results for the activity of derivatives on tillers, reported in Table 6 show that the average numbers of tillers were significant for all varieties. WAB638-1 plants had the highest numbers with T7 (14 tillers/foot or 366.6%), followed by T14 (12 tillers/foot or 300%), T19 and T20 (11 tillers/foot or 266.6%). These treatments

were not statistically different from each other. The number of tillers produced by plants treated with T1, T2, T3, T5, T6, T15, T16 and T17 ranged from 3 to 4 tillers/foot with no difference from the control which also produced 3 tillers/foot.

With C6, all treatments promoted tillering compared to the control which produced 7 tillers/foot.

However, the most favorable was T8 (19 heels/feet equivalent to 171.4% compared to the control). The following treatment T14 increased the formation of this variable by 142% (17 tillers/foot).

In NERICA 2, T4 (2 tillers/plant or -66.70%) had an inhibitory effect on tillers production. The treatments T16 to T18; T10 to T12; T5, T6 and T1 to T3 were close to the control. The T13 plants that produced 15 tillers/plant, an increase of 150%, tilled more. They were followed by T20, T21 (13 tillers/plant or 116.70%); T14, T15 (11 tillers/plant or 83.30%) and T7, T8 (12 tillers/plant). heir effect was subjacent. Tiller production had a gain of 116.7; 80.3 and 100%, respectively. The improvement in tillering obtained would reflect the stimulating effect of these analogues on the internal cytokines of the varieties, which favored the differentiation of the buds, their bud break, and their emergence. Similar results of increasing the number of tillers have been obtained by spraying rice with naphthalene acetic acid and pre-treating rice grains with indole butyric acid [35,36,37, 29,20,30].

3.5 Relationships between Derivatives, Concentrations and Parameters Studied

Principal component analysis (PCA) was used to characterize the treatments in order to select the most efficient ones on plant growth and development. The projection of variables and individuals in the factorial plant defined two axes, F1 and F2 for each variety.

These two axes express 96.93% (WAB638-1), 86.76% (C26) and 92.43% (NERICA 2) of the total variability (WAB638-1: Fig. 1, C26: Fig. 2, NERICA 2: Fig. 3). Individuals favoring growth and development parameters are those far from the origin of the axis, close to each other and clustered around the variables. These individuals were grouped into three groups for each variety.

Table 4. Effect of auxin derivatives on girth

Treatments	WAB638-1		C26		NERICA2	
	Circumference (cm)	AR (%)	Circumference (cm)	AR (%)	Circumference (cm)	AR (%)
T0	10.70 fg	-	10.10 gh	-	8.90 cd	-
T1	10.50 fg	-1.87	11.10 gh	9.90	6.80 ef	-23.60
T2	12.20 f	14.02	1150 gh	13.86	8.00 ef	-10.11
T3	11.70 fg	9.35	10.40 gh	2.97	6.00 ef	-32.58
T4	11.80 fg	10.28	11.60 gh	14.85	600 ef	-32.58
T5	11.70 fg	9.35	11.70 gh	15.84	6.00 ef	-32.58
T6	11.90 fg	11.21	12.20 fg	20.79	6.90 ef	-22.47
T7	15.20 cd	42.06	15.60 bc	54.46	10.60 bc	19.10
T8	18.10 b	69.16	14.20 cd	40.59	10.30 bc	15.73
T9	13.60 e	27.10	14.00 cd	38.61	8.70 cd	-2.24
T10	15.40 cd	43.93	12.20 fg	20.79	7.20 ef	-19.10
T11	15.00 cd	40.19	13.30 de	31.68	9.40 cd	5.62
T12	14.70 de	37.38	15.20 bc	50.50	8.70 cd	-2.25
T13	11.70 fg	9.35	13.00 ef	28.71	11.40 ab	28.09
T14	16.20 cd	51.40	16.70 b	65.35	10.40 bc	16.85
T15	10.50 fg	-1.87	10.20 gh	0.99	10.40 bc	16.85
T16	10.20 g	-4.67	11.60 gh	14.85	5.40 f	-39.33
T17	11.30 fg	5.61	9.70 h	-3.96	5.70 ef	-35.96
T18	11.50 fg	7.48	10.90 gh	7.92	7.10 ef	-20.22
T19	16.60 c	55.14	13.20 ef	30.69	12.00 a	34.83
T20	19.30 a	80.37	12.10 gh	19.80	11.40 ab	28.09
T21	15.70 cd	46.73	18.50 a	83,17	10.10 cd	13.48
Newman						

Treatments	WAB638-1		C26		NERICA2	
	Circumference (cm)	AR (%)	Circumference (cm)	AR (%)	Circumference (cm)	AR (%)
Keuls P < 0.05	0.00		0.01		0.00	

Values with different letters in the same column differ at the 5% level of the Newman-Keuls test
AR: rate of increase relative to controls, T0 : control (water),T1 : 2.5-DMPAA 10^{-5} M, T2 : 2.5-DMPAA 10^{-7} M, T3 : 2.5-DMPAA 10^{-7} M, T4 : 2,4-DCPAA 10^{-5} M, T5 : 2,4-DCPAA 10^{-7} M, T6 : 2,4-DCPAA 10^{-9} M, T7 : 2,4-DMPPA 10^{-5} M, T8: 2.4-DMPPA 10^{-7} M, T9 : 2.4-DMPPA 10^{-9} M, T10 : ACPA 10^{-5} M , T11 : ACPA 10^{-7} M, T12 : ACPA 10^{-7} M, T13 : PPPA 10^{-5} M, T14 : PPPA 10^{-7} M, T15 : PPPA 10^{-9} M, T16 : ACMA 10^{-5} M, T17 : ACMA 10^{-7} M, T18 : ACMA 10^{-9} M, T19 : ACMPP 10^{-5} M , T20 : ACMPP 10^{-7} M and T21 : ACMPP 10^{-9} M

Table 5. Influence of auxin derivatives on vigor index

Treatments	WAB638-1		C26		NERICA2	
	Strength index	AR (%)	Strength index	AR (%)	Strength index	AR (%)
T0	4.20 de	-	4.0 fg	-	3.30 cd	-
T1	4.10 e	-2.38	4.00 fg	0.00	3.40 cd	3.03
T2	4.20 de	0.00	4.10 fg	2.50	3.20 cd	-3.03
T3	4.20 de	0.00	3.90 g	-2.50	3.20 cd	-3.03
T4	4.20 de	0.00	4.00 fg	0.00	3,20 cd	-3.03
T5	4.20 de	0.00	4.00 fg	0.00	3.20 cd	-3.03
T6	4.20 de	0.00	4.10 gf	2.50	3.40 cd	3.03
T7	4.50 bc	7.14	4.30 a	7.50	3.60 ab	9.09
T8	4.60 a	9.52	4.20 c	5.00	3.60 bc	9.09
T9	4.40 c	4.76	4.20 c	5.00	3.20 cd	-3.03
T10	4.40 bc	4.76	4.10 ef	2.50	3.40 ad	3.03
T11	4.30 c	2.38	4.20 c	5.00	3.60 ab	9.09
T12	4.40 c	4.76	4.30 ab	7.50	3.40 ad	3.03
T13	4.20 de	0.00	4.10 cd	2.50	3.80 a	15.15
T14	4.50 b	7.14	4.30 a	7.50	3.60 ab	9.09
T15	4.20 de	0.00	3.90 g	-2.50	3.60 ab	9.09
T16	4.10 e	-2.38	4.00 fg	0.00	2.90 d	-12.12
T17	4.20 de	0.00	3.90 g	-2.50	3.10 cd	-6.06
T18	4.20 de	0.00	4.00 fg	0.00	3.30 cd	0.00
T19	4.50 b	7.14	4.10 de	2.50	3.80 a	15.15
T20	4.60 a	9.52	4.10 de	2.50	3.70 a	12.12
T21	4.40 bc	4.76	4.40 a	10.00	3.70 a	12.12
Newman Keuls P < 0.05	0.00		0.00		0.00	

Values with different letters in the same column differ at the 5% level of the Newman-Keuls test
AR: rate of increase relative to controls, T0 : control (water),T1 : 2.5-DMPAA 10^{-5} M, T2 : 2.5-DMPAA 10^{-7} M, T3 : 2.5-DMPAA 10^{-7} M, T4 : 2,4-DCPAA 10^{-5} M, T5 : 2,4-DCPAA 10^{-7} M, T6 : 2,4-DCPAA 10^{-9} M, T7 : 2,4-DMPPA 10^{-5} M, T8: 2.4-DMPPA 10^{-7} M, T9 : 2.4-DMPPA 10^{-9} M, T10 : ACPA 10^{-5} M , T11 : ACPA 10^{-7} M, T12 : ACPA 10^{-7} M, T13 : PPPA 10^{-5} M, T14 : PPPA 10^{-7} M, T15 : PPPA 10^{-9} M, T16 : ACMA 10^{-5} M, T17 : ACMA 10^{-7} M, T18 : ACMA 10^{-9} M, T19 : ACMPP 10^{-5} M , T20 : ACMPP 10^{-7} M and T21 : ACMPP 10^{-9} M

Table 6. Effect of auxin derivatives on the amount of tillers

Treatments	WAB638-1		C26		NERICA2	
	Heels/foot	AR (%)	Heels/foot	AR (%)	Heels/foot	AR (%)
T0	3.00 e	-	7.00 i	-	6.00 bc	-
T1	3.00 e	0.00	10.00 gh	42.70	6.00 bc	0.00
T2	3.00 e	0.00	9.00 gh	28.60	5.00 bc	-16.70
T3	3.00 e	0.00	10.00 gh	42.90	5.00 bc	-16.70

Treatments	WAB638-1		C26		NERICA2	
	Heels/foot	AR (%)	Heels/foot	AR (%)	Heels/foot	AR (%)
T4	6.00 d	100.00	13.00 de	85.70	2.00 c	-66.70
T5	3.00 e	0.00	11.00 fg	57.10	6.00 bc	0.00
T6	4.00 e	33.30	11.00 f	57.10	6.00 bc	0.00
T7	14.00 a	366.60	14.00 c	100,0	12.0 ab	100.00
T8	9.00 c	200.00	19.00 a	171.40	12.00 ab	100.00
T9	8.00 c	166.60	12.00 ef	71.40	10.00 b	66.70
T10	9.00 c	200.00	10.00 gh	42.90	5.00 bc	-16.70
T11	8.00 c	166.60	10.00 gh	42.90	6.00 bc	0.00
T12	10.00 c	233.30	14.00 cd	100.00	5.00 bc	-16.70
T13	8.00 c	166.60	15.00 c	114.30	15.00 a	150.00
T14	12.00 b	300.00	17.00 b	142.90	11.00 ab	83.30
T15	4.00 e	33.30	11.00 fg	57.10	11.00 ab	83.30
T16	4.00 e	33.30	10.00 gh	42.90	6.00 bc	0.00
T17	4.00 e	33.3	10.00 gh	42.90	5.00 bc	-16.66
T18	6.00 d	100.0	11.00 gh	57.10	6.00 bc	0.00
T19	11.00 b	266.6	13.00 d	85.70	15.00 a	150.00
T20	11.00 b	266.60	13.00 d	85.70	13.00 ab	116.70
T21	9.00 c	200.00	11.00 f	57.10	13.00 ab	116.70
Newman Keuls P < 0.05	0.00		0.00		0.00	

Values with different letters in the same column differ at the 5% level of the Newman-Keuls test
AR: rate of increase relative to controls, T0 : control (water),T1 : 2.5-DMPAA 10^{-5} M, T2 : 2.5-DMPAA 10^{-7} M, T3 : 2.5-DMPAA 10^{-7} M, T4 : 2,4-DCPAA 10^{-5} M, T5 : 2,4-DCPAA 10^{-7} M, T6 : 2,4-DCPAA 10^{-9} M, T7 : 2,4-DMPPA 10^{-5} M, T8: 2.4-DMPPA 10^{-7} M, T9 : 2.4-DMPPA 10^{-9} M, T10 : ACPA 10^{-5} M , T11 : ACPA 10^{-7} M, T12 : ACPA 10^{-7} M, T13 : PPPA 10^{-5} M, T14 : PPPA 10^{-7} M, T15 : PPPA 10^{-9} M, T16 : ACMA 10^{-5} M, T17 : ACMA 10^{-7} M, T18 : ACMA 10^{-9} M, T19 : ACMPP 10^{-5} M , T20 : ACMPP 10^{-7} M and T21 : ACMPP 10^{-9} M

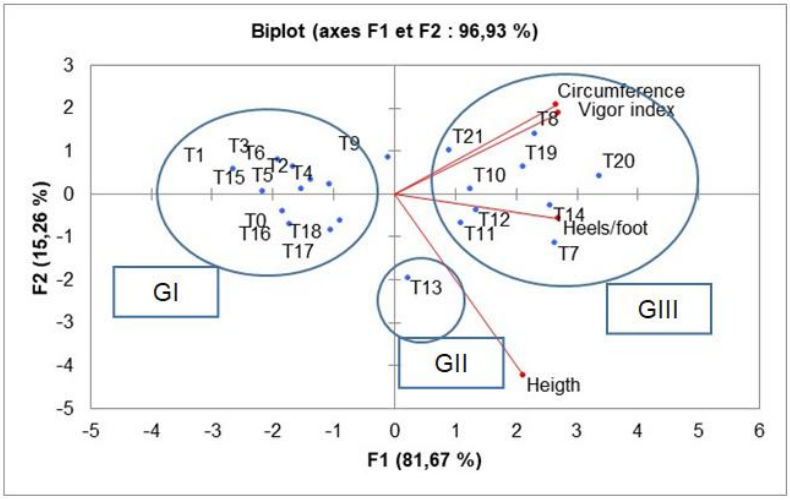

Fig. 2. Representation of the WAB638-1 variety variables, derivatives and concentrations on the F1 and F2 axes using PCA

T0 : control (water),T1 : 2.5-DMPAA 10^{-5} M, T2 : 2.5-DMPAA 10^{-7} M, T3 : 2.5-DMPAA 10^{-7} M, T4 : 2,4-DCPAA 10^{-5} M, T5 : 2,4-DCPAA 10^{-7} M, T6 : 2,4-DCPAA 10^{-9} M, T7 : 2,4-DMPPA 10^{-5} M, T8: 2.4-DMPPA 10^{-7} M, T9 : 2.4-DMPPA 10^{-9} M, T10 : ACPA 10^{-5} M , T11 : ACPA 10^{-7} M, T12 : ACPA 10^{-7} M, T13 : PPPA 10^{-5} M, T14 : PPPA 10^{-7} M, T15 : PPPA 10^{-9} M, T16 : ACMA 10^{-5} M, T17 : ACMA 10^{-7} M, T18 : ACMA 10^{-9} M, T19 : ACMPP 10^{-5} M , T20 : ACMPP 10^{-7} M and T21 : ACMPP 10^{-9} M

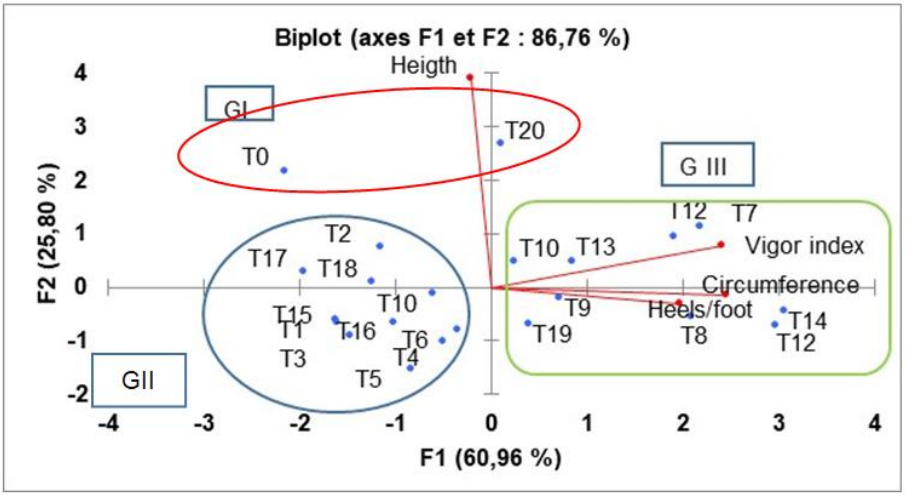

Fig. 3. Representation of the C26 variety variables, derivatives and concentrations on the F1 and F2 axes using PCA

T0 : control (water),T1 : 2.5-DMPAA 10^{-5} M, T2 : 2.5-DMPAA 10^{-7} M, T3 : 2.5-DMPAA 10^{-7} M, T4 : 2,4-DCPAA 10^{-5} M, T5 : 2,4-DCPAA 10^{-7} M, T6 : 2,4-DCPAA 10^{-9} M, T7 : 2,4-DMPPA 10^{-5} M, T8: 2.4-DMPPA 10^{-7} M, T9 : 2.4-DMPPA 10^{-9} M, T10 : ACPA 10^{-5} M , T11 : ACPA 10^{-7} M, T12 : ACPA 10^{-7} M, T13 : PPPA 10^{-5} M, T14 : PPPA 10^{-7} M, T15 : PPPA 10^{-9} M, T16 : ACMA 10^{-5} M, T17 : ACMA 10^{-7} M, T18 : ACMA 10^{-9} M, T19 : ACMPP 10^{-5} M , T20 : ACMPP 10^{-7} M and T21 : ACMPP 10^{-9} M

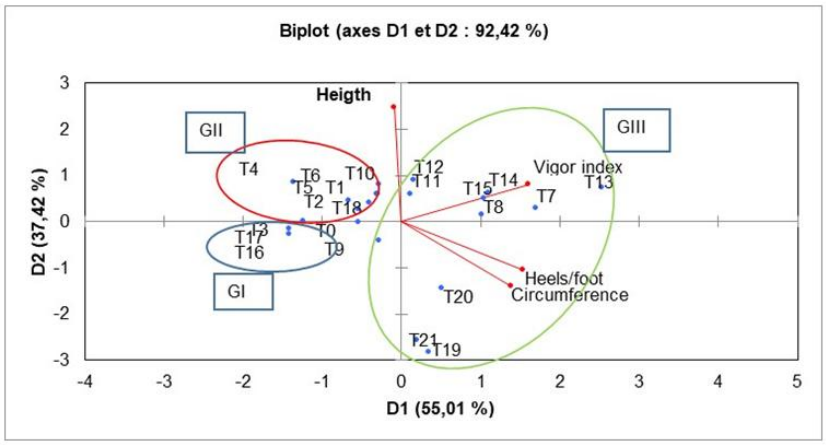

Fig. 4. Representation of the Nerica 2 variety variables, derivatives and concentrations on the F1 and F2 axes using PCA

T0 : control (water),T1 : 2.5-DMPAA 10^{-5} M, T2 : 2.5-DMPAA 10^{-7} M, T3 : 2.5-DMPAA 10^{-7} M, T4 : 2,4-DCPAA 10^{-5} M, T5 : 2,4-DCPAA 10^{-7} M, T6 : 2,4-DCPAA 10^{-9} M, T7 : 2,4-DMPPA 10^{-5} M, T8: 2.4-DMPPA 10^{-7} M, T9 : 2.4-DMPPA 10^{-9} M, T10 : ACPA 10^{-5} M , T11 : ACPA 10^{-7} M, T12 : ACPA 10^{-7} M, T13 : PPPA 10^{-5} M, T14 : PPPA 10^{-7} M, T15 : PPPA 10^{-9} M, T16 : ACMA 10^{-5} M, T17 : ACMA 10^{-7} M, T18 : ACMA 10^{-9} M, T19 : ACMPP 10^{-5} M , T20 : ACMPP 10^{-7} M and T21 : ACMPP 10^{-9} M

In WAB638-1 all variables are positively correlated with the F1 axis. The 1st group (GI) is constituted by T1, T3, T6 , T5, T4, T2, T16, T17, T18, T15 and T9 they had an effect close to the control. The 2nd group (GII) improving height included the T13. Those in the 3rd group (GIII) formed by treatments T11, T12, T10, T21, T19, T20, T7, T14 and T8 had greater activity on tillering, girth, and vigor index.

In the C26 variety, apart from height which is positively correlated to the F2 axis, all other variables are positively correlated with the F1 axis. Group I (GI) includes the T20 treatment (had the same effect as the TC0 control. Group II (GII) consists of treatments T2, T17, T18, T10, T15, T1, T16, T6, T3, T4, and T5 did not have any effect on the different parameters.

Group III (GIII) includes treatments T7, T12, T13, T11, T9, T19, T20, T14 and T21. These treatments promoted vigor, girth and tillering indices.

As for the variety NERICA 2, the F1 axis is correlated to the number of tillers/plant and circumference and F2 to the vigor index and height. Group I (GI) treatments composed of T2, T9, T3, T11, T17 had an effect close to the control. The 2nd group (GII) promoting height consisted of treatments T10, T12, T1, T6, T4, T5, T18, The 3rd group (GIII) grouping treatments T21, T19, T20, T15, T8, T7, T14 T13 and positively induced vigor index, tillering and girth. Treatment effects varied among varieties. At the individual variety level, Group I (GI) treatments had no effect. Those of group III (GIII) that positively induced both tillering, girth and vigor index. Among them, the influence of treatments from propanoic chain derivatives, T19, T20, T21, T7, T8, T9 and T13, T14, T15 was more marked. These results show the diversity of actions of growth regulators. Studies have shown that exogenous application of auxins induces different responses depending on their concentration and the effect of hormones depends on the cell that receives them. For the same group of substances, the responses can vary according to the development of a plant and between varieties of the same crop [38]. For the same group of substances, the responses can vary on the development of a plant and on the varieties of the same crop. These same results have been These same results were observed in work carried out in hydroponic culture of plantain flakes with phenoxyacetic acid derivatives. The results showed that some treatments had the same effect as the control [39].

4. CONCLUSION

Phenoxyacetic acid derivatives are auxin-like growth regulators. They were applied to the leaves from 15 to 25 days after sowing with an interval of 5 days. The regutates showed that their effect depended on the concentrations, the varieties and the parameters evaluated. Differences were clearly seen between the subjects and the controls. The effects of treatments T13, T14, T15, T7, T8, T9, T19, T20 and T21 from propanoic chain derivatives, ACPP, ACMPP and 2.4-DMPPA were more marked. Among them, T13, T14, T7, T8, T20 and T19 were found to be the most improving vegetative parameters of the rice varieties and will be evaluated in the field on grain recovery.

ACKNOWLEDGEMENTS

This research work has been financed by our own funds. First of all, thanks to the Felix HOUPHOUET-BOYGNY University which allowed our registration from the first year to the PhD year. Many thanks to Pr. SISSOUMA who put these molecules at our disposal and to Dr. Aboudramane KONE for the synthesis of these compounds. Thanks to Pr. Turquin for the supervision of this work and for the financial contribution. We are also grateful to Dr. Didier Konan KOUAME who kindly joined Prof. Turquin to direct the work and the correction of this manuscript. We are also grateful to Dr. Victor Tiéba WOUATTARA for all his encouragement, his financial help for the setting up of the trial, the transportation as well as for the data collection and the statistical analyses.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kwanze MF, Mohapatra S, Kormawa P, Keya s, Bruce-Oliver s rice development in subsaharan africa. Journal of Science Food and Agriculture. 2006;86.
2. Soumare M, Traoré S, Havard M. Population growth, food security and access to health and education in the cotton zone of Mali Cah. Agric. 2020;29 (40).
3. Kouame K, Ake S, Yte W, Doumbia S, Konan K E, Kouassi NA, Kone B,Sekou D. Determination of the optimal dose of potassium fertilizer under oil palm (*Elaeis guineensis* jacq.) cultivation in southeastern Côte d'Ivoire conditions: case of plant material under extension. European Scientific Journal. 2014;10 (18):1-19.
4. Dembélé D. Impact of hygienized human urine on adventitious and productivity of irrigated rice Oryza sativa, Bouake 189 in northern Côte d'Ivoire. Master 2 thesis, Nangui Abrogoua University; 2013.
5. Kouamé, Akpaud. Presentation on infrastructure and water control; 2018. Accessed March 5, 2022. Available:https://riceforafrica.net/joomla/images/stories/PDF/gp_ci_fre2018.
6. Al-Hassan RM, Agbekornu HG, Sarpong, DB. Consumer preference for rice quality

characteristics in Accra and the effects of these preferences on price. Agricultural and Food Science Journal of Ghana. 2008;7.
7. Gianfagna TJ. Natural and synthetic growth regulators and their use in horticultural and agronomic crops, In Davis PJ (Ed). Plant hormones and their role in plant growth and develeopment. Martinus Nijhoff Publishers, Dordecht, Boston, Lancaster; 1987.
8. Ekamber K, Kumar MP. Hormonal regulation of tiller dynamics in differentially-tillering rice cultivars. Plant Growth Regulators. 2007;53.
9. Shah SH, Ahmad I, Samiullah. Effect of gibberellic acid spray on growth, nutrient uptake and yield attributes at various growth stages of black cumin (*Nigella sativa* L.). Asian Journal of Plant Science. 2006;5.
10. Abel S, Theologis A. Odyssey of Auxin. In: Perspectives in Biology. Estelle M, Weijers D, Ljung K, Leysers O (Eds). Cold Spring Harbour Laboratory Press, USA; 2010.
11. Sakamoto T, Miura K, Tatsumi T, Ueguchitanaka M, Ishiyama K. An overview of gibberellin metabolism enzyme and their related mutants in rice. Plant Physiology. 2004;134.
12. Sun T. Gibberellin signal transduction in stem elongation and leaf growth. In: Plant Hormones: biosynthesis, signal transduction and action. Davies PJ (Ed). Kluwer Academic Publishers, Dordrecht, The Netherlands; 2004.
13. Rajendra B, Jones Jonathan DG. Role of plant hormones in plant defense responses. Plant Molecular Biology. 2009;69.
14. Sakuma S, Schnurbusch T. Of floral fortune: tinkering with the grain yield potential of cereal crops. New Phytologist. 2019;(225):1873-1882.
15. Iqtidar H, Abdul AK, Imam B, Ejaz AK, Sheheryar. Effect of naphthalene acetic acid (naa) on grain yield and bioeconomic efficiency of coarse rice (*Oryza sativa* l.). Pak. J. Bot. in 2021;53(6):2017-2023.
16. Turquin L, Ake S, Anno P. Effects of auxin drifts on the production of plantain cv Horn 1 in Côte d'Ivoire. Sciences et Techniques, Sciences naturelles. et agronomie. 2007;29(1-2).
17. Koffi JK, Dje BDPV, Vroh BTA, Kpangui KB, Adou YCY. Exploitation and socio-economic importance of china bamboo, Bambusa vulgaris Schrad. ex J.C. Wendl. (Poaceae) in the Agnéby-Tiassa region: The case of Azaguié Sub-Prefecture (South-East of Côte d'Ivoire), International Journal Biology Chemistry Science. 2017;(11):2887-2900.
18. Ballo K C. Impacts of potassium fertilization on oil palm (*Elaeis guineensis* jacq.) yield components and soil characteristics: Case of ferralsols in southern Côte d'Ivoire. PhD thesis, University of Cocody, Abidjan, Ivory Coast; 2009.
19. Kouassi B. Analysis of the determinants of choice and adoption of improved rice varieties in the Gagnoa and Korhogo areas. Dissertation, INPHB. Côte d'ivoire; 2019.
20. Angladette A. Le riz. Maisonneuve et Larose. Paris, France; 1966.
21. Kouassi YF, Gbogouri GA, N'guessan KA, Bilgo A, Pascal KT, Angui, Ama TJ. Effects of organic and organo-mineral organic and organo-mineral fertilizers on soybean productivity in the savanna zone of Côte d'Ivoire African Agronomy. 2019;31(1):1-12.
22. Zimbahl RL. An history of weed Sciences in US lifes Sciences agricultural and biologicol Sciences: 1 # edition; 2010.
23. Boro. A comparative study of the agronomic and economic performance of the intensive rice system and the peasant practices of the Kou Valley in Burkina Faso. Université Polytechnique de Bobo-Dioulasso (UPB); 2015.
24. Kouakou K R. Evaluation of the productivity of two vivo methods (seedlings from stem fragments and propagation on of stem and multiplication on dehulled stumps) and biochemical study of the formation of plantain vivo plants [*Musa paradisiaca* L. (Musaceae)] Thesis in Biological Sciences of the University Nangui Abrogoua; 2020.
25. Amin AA, Gharib FA, Abouziena HF, Dawood MG. Role of indole-3-butyric acid or/and of putrescine in improving productivity of chickpea (*Cicer arientinum* L.) plants. Pakistan Journal of Biological Sciences. 2013;(16):1894-1903.
26. Soomro AS, Mazari, Impact of plant growth regulators on yield and yield components of rice (*Oryza sativa* L) under field conditions. Int. J. Appl. Sci. Biotechnol. SN. 2020;8(3):318-322.

27. Aloni R, Aloni E, Langhans M, Ullrich CI. Role of cytokinin and auxin in the shaping of root architecture: Regulation of vascular differentiation, lateral root initiation, apical root dominance and root gravitropism. Annals of Botany. 2006;(97):883-893
28. Dubrovsky JG, Doerner PW, Colon-Carmona A, Rost L. Pericycle cell proliferation and lateral root initiation in Arabidopsis. Plant Physiology. 2000;(124):1648-1657.
29. Leitz M. A. Vessel-element dimensions and frequency within the most current growth increment along the length of Eucalyptus globulus stems. Arbres Structure et Fonction. 2001;(15):353-357.
30. Lepengue A N, Ontod T, Mbadoumou B, Mouaragadja I, AKE S, M'Batchi B. Effect of auxinic pretreatments on the growth of okra plants in Gabon. Agronomie Africaine. 2011;23(3):237 - 245.
31. Digby J, Wareing PF. The effect of applied growth hormones on cambial division and differentiation of cambial derivatives. Annals of Botany. 1966;(30):539-548.
32. Baker CM, Wetzstein HY. Influence of auxin type and concentration on peanut somatic embryogenesis. Pl. Cell Tissue Organ Cult. 2004;36(3):361-368.
33. Staswick P E, Serban B, Rowe M. Characterization and rooting ability of indole 3-acetic acid conjugates formed during rooting of mung bean cuttings. Pl. Physiol. 2005;91:1080-1084.
34. Xiaomin W, Huabin Z, Qiyuan T, Wenwei M, Junjie M. Effects of Gibberellin acid application after Anthesison Seed Vigor of Indica Hybrid Rice. Agronomy journal; 2019.
35. Bakhsh I, Himayat UK, Mohammad QK, Javaria S. Effect of naphthalene acetic acid and phosphorus levels on yield potential of transplanted coarse rice. Sarhad J. Agric. Faculty of Agriculture, Gomal University, Dera Ismail Khan - Pakistan. 2011;27(2):161-1655.
36. Vahid G, Moradshahi A, Mohammad J R, Karampour A. Improving yield and yield components of rice (*Oryza sativa* L.) by indolebutyric acid (IBA), gibberellic acid (GA) and salicylic acid (SA) pre-sowing seed treatments. American-Eurasian J. Agric. Et Environ. Sci. 2013;13(6): 872-876.
37. Thimann K V. Auxins. In: Wilkins, M. B., ed. Physiology of plant growth and development. London: McGraw-Hill. 1969;1-45.
38. Turquin L.. Contribution to the study of the growth and development of b-type shoots in plantain type b in plantain (Musa AAB cv Horn 1): activity of some structural analogues of phenoxyacetic acid (PAA). Thesis of Doctorate in Natural Sciences. University of Aix-Marseille; 1998.
39. Caralde RA, Salas RA. Yield and quality of'iceberg'lettuce applied with novel organic nutrient solution under aggregate hydroponic system. InII Southeast Asia Symposium on Quality Management in Postharvest Systems 1088. 2013; 473-476).

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/97403