

## Original Research Article

# Screening of Phenoxyacetic Acid Derivatives In Rainfed Rice

Comment [AM1]: I suggest: Screening of the effect of Phenoxyacetic Acid Derivatives In Rainfed Rice, because you are not detected phenoxyacetic acids but evaluated them on rice

### ABSTRACT

In Côte d'Ivoire, the yield of rainfed rice (*Oryza sativa*) contributing to more than 80% of production is low. To address this constraint, seven phenoxyacetic acid derivatives were evaluated. The trial was conducted in Azaguié for two months under rainfed conditions and in a semi-controlled environment on vegetative material of three rice varieties (WAB638-1, C26 and NERICA 2). The design was a split-plot and observations were made on height, girth, vigor index and tillering. Results showed that the number of tillers/plant of WAB638-1 was improved to: 366.60 % by 2.4-DMPAA  $10^{-5}$  M (WAB638-1), (171%) by 2.4-DMPPA  $10^{-7}$  M (C26) and 150% by ACPP  $10^{-5}$  M and ACMPP  $10^{-5}$  M (NERICA 2). Circumference was increased: (80.37%) by ACMPP  $10^{-7}$  M (WAB638-1), (83.17%) by ACMPP  $10^{-9}$  M (C26) and (38.83%) by ACMPP  $10^{-5}$  M (NERICA 2). The height of WAB638-1 was greater with: 6.76% by 2.4-DMPAA  $10^{-5}$  M and ACPP  $10^{-5}$  M (6.36%) followed by ACPP  $10^{-7}$  M (4.92%) and reduced by the derivatives 2.5-DMPAA and 2.4-DCPAA. All derivatives inhibited C26 size except ACMPPA  $10^{-7}$  M which was identical to the control. With NERICA 2, ACPA  $10^{-7}$  M had the greatest size (22.39%). The vigor index was greater with 2.4-DMPP  $10^{-7}$  M (9.52%) and ACMPP  $10^{-7}$  M (9.52%) at WAB638-1, ACMPP  $10^{-7}$  M (10.40%), ACPP  $10^{-7}$  M (7.5%) and 2.4-DMPPA  $10^{-7}$  M (7.5%) for C26 and ACPP  $10^{-5}$  M (15.15%) and ACMPP  $10^{-7}$  and  $10^{-9}$  M (12.12%) regarding NERICA 2. Based on these results, the 2.4-DMPP, ACMPP and ACPP derivatives were retained at  $10^{-5}$  M and  $10^{-7}$  M concentrations.

Keywords: rice, *Oryza sativa* L, growth regulators, auxin derivatives, Côte d'Ivoire

Comment [AM2]: ?

### 1. INTRODUCTION

As the world's population increases, agricultural production should increase proportionally in order to feed it. This increase could be achieved by increasing the area of arable land or by improving yields. Nowadays, with the deforestation linked to rapid urbanization, only a tiny region of the planet can significantly increase the agricultural area [1]. Therefore, improving the yield and productivity of crops, especially rice, on arable land is becoming a necessity. In sub-Saharan Africa, particularly in Côte d'Ivoire, rice is consumed in most households at least once a day and is replacing traditional staple foods [2]. As the third most important food crop after yam and cassava, rice contributes to about 17% of total agricultural employability, coming in third place after cocoa and market gardening; it contributes to 9.9% of Ivorian GDP [3]. The improvement of

its grain yield is traditionally done by fertilizers including organic matter (manure, droppings, liquid manure...), green manures (leguminous plants fixing atmospheric nitrogen) and chemical NPK fertilizers implemented by agricultural research [4]. Despite these inputs, the average yield (1.24 t/ha) of rainfed rice cultivation in rural areas remains low [5]. This suggests the adoption of new technologies that are environmentally friendly, cost-effective and easy to use, to enable rice varieties to express their grain yield potential. This could be achieved through genetic improvement, innovative cropping systems, grafting, growth promotion by microorganisms, and plant growth regulators [6]. Since their discovery, natural and artificial plant growth regulators are increasingly used in horticulture and agriculture to modify crop plants [7]. Indeed, they are involved in various metabolic processes of plants. Among these [phyto](#)hormones, auxins constitute a class controlling plant growth and development processes [8]. The effect of improving fruit formation by exogenous supply of auxins has been demonstrated in tomato [9]. One of the auxin derivatives notably naphthalene acetic acid optimized the potential grain yield of rice [10, 11]. The use of some phenoxyacetic acid derivatives in banana improved the fruit yield of this crop [12]. In order to fill the rice production gap in Côte d'Ivoire, it seemed appropriate to evaluate the effect of other phenoxyacetic acid derivatives on the yield of three rice varieties.

## 2. MATERIAL AND METHODS

### 2.1 Experimental site

The trial was conducted at Abbé, a crossroads with geographic coordinates of 5°37'39" North and 4°01'31" West. Abbé is part of the municipality of Azaguié 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 [13]. The Attean type climate is characterized by two rainy seasons (average rainfall of 1400 mm) and two dry seasons. The long rainy season extends from May to mid-July and the short one from mid-September to October. The long dry season begins in November and ends in April; the short dry season covers the period from mid-July to mid-September [14]. Rainfall is abundant and the average annual temperature is 28°C [1]. The vegetation is fallow and the soil is clayey-sandy with a fairly consistent texture. The soil has an acid pH (5.5) with a low organic matter content (1.44%). Its physico-chemical composition varies according to the horizon explored. Thus, the C/N ratio is 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<sup>-1</sup>, the assimilable phosphorus content is estimated at 53 ppm, carbon varies from 5.78 to 3.38 g.kg<sup>-1</sup> and nitrogen from 0.11 to 0.05 g.kg<sup>-1</sup> [1].

### 2.2 Material

The plant material consisted of three rice varieties developed by AfricaRice

The variety WAB638-1, selected from an aromatic local population, can be grown under both rainfed 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 1000 grain mass of 24.1 g [15].

NERICA is the result of an interspecific cross between *Oryza sativa* (L.), a high-yielding Asian rice variety, and *Oryza glaberrima* (Steud), a rice variety originating from Africa that is more resistant to biotic stresses [16]. NERICA 2 is a cross between WAB56-104/CG 14//2 and WAB56-104. It is grown under rainfed conditions with an average cycle of 95 to 100 days. The vegetative phase lasts from 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 variety C26 of pure lineage, is tolerant to the drought. It is cultivated under irrigation conditions and in the lowlands. It is a variety with an average cycle of 102 days. It has an average height at maturity of 102 cm, a yield of 4.5 to 6 t/ha and a 1000 grain weight of 22.25 g [17].

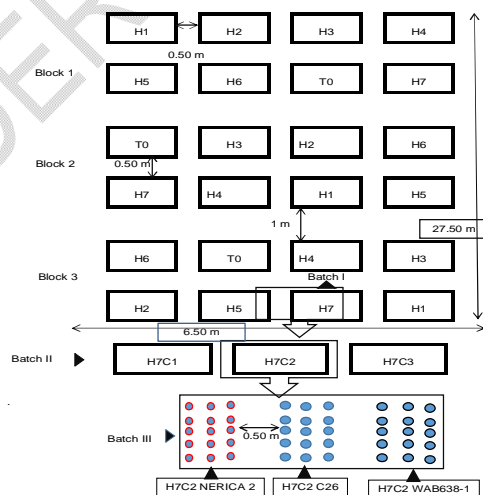
WAB638-1 was chosen because it is highly valued by the population for its taste; NERICA 2 and C26 for their earliness.

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:

- ✓ phenoxyacetic acid (PCAA);
- ✓ chlorinated derivative: 2,4-dichlorophenoxyacetic acid (2,4-DCPAA);
- ✓ methyl derivatives:
  - 2,5-dimethylphenoxyacetic acid (2,5-DMPAA);
  - methylphenoxyacetic acid (ACMA);
- ✓ derivatives with propanoic chains
  - simple propanoic: phenoxypropanoic acid (PPPA);
  - propanoic and methyl:
    - 2,4-dimethylphenoxypropanoic acid (2,4-DMPPA);
    - methylphenoxypropanoic acid (ACMPP).

### 2.3 Methods

The trial was conducted in a semi-controlled environment. The experimental design used was a randomized split-plot with 3 replicates with three factors: derivatives (ACPA, 2,4-DCPAA, 2,5-DMPAA, ACMA, ACPP, ACPP and ACMPP), concentrations ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M) and varieties (WAB638-1, C26 and NERICA 2). The experimental units consisted of elementary lots of 135 plants in bags of 28 x 20 cm filled with soil from the 0-20 cm sterilized horizon. They were spaced 0.5 m apart and subdivided into three subplots of 45 plants, each representing a hormone at one of the concentrations. These subplots were also made up of three batches of 15 plants spaced 0.5 m apart representing a hormone with a concentration associated with each variety and constituted the treatments (Figure 1). The total area of the experiment was 177.30 m<sup>2</sup> or 27.30 m x 6.5 m. Two weedings were done 21 and 40 days after sowing (jas); the plants were watered every 2 days according to the needs of the crop. The trial was conducted over a period of 60 d. Solutions of  $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M concentrations of the derivatives, obtained by diluting the stock solutions to 10<sup>-3</sup> M, were applied to the rice plants in the early morning. Three foliar applications were made from day 15 to day 25 with a spacing of 5 days.



**Figure 1: Experimental setup**

H1: 2.5-DMPAA, H2 : 2.4-DCPAA, H3 : 2.4-DMPPA, H4 : ACPA, H5 : ACPP, H6 : ACMA, H7 : ACMPP  
V1. WAB638-1, V2. C26, V3. NERICA 2

Formatted: Italian (Italy)

#### 2.4 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 started on day 30 and were taken every 15 days.

#### 2.5 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).

Formatted: Indent: First line: 0.2"

#### 2.6 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.

#### 2.7 Number of tillers

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

#### 2.8 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  $C \pi=D$ .

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

C: circumference (cm), H: height (cm) and  $\pi = 3.14$

#### 2.9 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 [18].

$TA (\%) = [(T_n - T_0) / T_0] \times 100$

T<sub>0</sub>: height, girth or tillering of control plants

T<sub>n</sub>: height, circumference or tillering of treated plants.

#### 2.10 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

#### 3.1 Height

Plant height and growth rates relative to the controls of the three varieties presented in Table 1. 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 (NERICA 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 the treatment 2.4-DMPAA  $10^{-5}$  M (104.17 cm) with an increase rate of (6.76%) and ACPP  $10^{-5}$  M (103.75 cm) for an increase rate of 6.36% followed by the treatment ACPP  $10^{-7}$  M which recorded a height of 102.42 cm (4.92 %). The lowest height was given by the 2.4-DCPAA  $10^{-9}$  M treatment (94.9 cm). The other treatments were intermediate.

For the C26 variety, the best sizes were recorded with the ACMPP  $10^{-7}$  M treatments (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 the ACPA treatment at  $10^{-7}$  M. It increased this parameter by 22.39% (103.39 cm) and the control plants with the lowest height. The derivatives 2.5-DMPAA and 2.4-DCPAA reduced, whatever the concentration, the height of the variety WAB638-1 and in C26. This variable was also reduced by all derivatives except  $10^{-7}$  M ACMPP. At concentrations of  $10^{-5}$  M and  $10^{-9}$  M, the compounds (2.4-DMPPA and ACPA) 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 [19] who obtained an improvement in the height of chickpea by spraying indole-3-butyric acid; as well as those of [20] 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 2). with WAB638-1, the lowest circumference, was observed with 2.5-DMPAA  $10^{-5}$  M. This value which was smaller was not statistically different from the control (10.70 cm). ACMPP  $10^{-7}$  M, allowed the plants to have the greatest radial growth (19.30 cm or 80.37%). It was followed by 2.4-DMPPA  $10^{-7}$  M (18.10 cm or 69.16%), ACMPP  $10^{-5}$  M (16.60 or 55.40%) and ACMPP  $10^{-7}$  M (16.20 cm and 51.40%). ACMPP  $10^{-5}$  M and ACMPP  $10^{-7}$  M belonging to the same group were statistically different from 2.4-DMPPA  $10^{-7}$  M. For variety C26, ACPA  $10^{-5}$  M whose mean

Table 1. Effect of auxin derivatives on height

Phenoxyacetic acid derivatives	Concentrations (M)	WAB638-1		C26		NERICA2	
		Height (cm)	AR (%)	Height (cm)	AR (%)	Height (cm)	AR (%)
Witnesses	C0: 0	97.58 de	-	80.33 a	-	84.40 b	-
2,5-DMPAA(H3)	C1: $10^{-5}$	95.08e	-2.56	64.50 gh	-19.68	98.00 ab	16..
	C2: $10^{-7}$	96.33 de	-1.33	67.08fg	-16.44	95.20 ab	12.80
	C3: $10^{-9}$	96.83 de	-4.92	57.50 i	-28.39	94.10 ab	11.49
2,4-DCPAA (H2)	C1: $10^{-5}$	96.25 de	-1.33	61.58 hi	-23.29	91.00 ab	7.82
	C2: $10^{-7}$	96.75de	-0.82	58.42 hi	-27.27	99.00 ab	17.30
	C3: $10^{-9}$	94.92 e	-2.77	62.42 hi	-22.29	99.00 ab	17.30
2,4-DMPPA (H6)	C1: $10^{-5}$	104.17 a	6.76	72.67 b	-9.46	86.30 ab	2.25
	C2: $10^{-7}$	98.33 cd	0.72	64.33 gh	-19.93	97.30 ab	15.28
	C3: $10^{-9}$	97.58 de	-0.41	65.25 gh	-18.80	100.90ab	19.55
ACPA (H1)	C1: $10^{-5}$	99.92 cd	2.36	66.08 fg	-17.68	92.00 ab	9.00
	C2: $10^{-7}$	102.00 bc	4.51	69.08 ef	-13.95	100.10 ab	18.60
	C3: $10^{-9}$	101.08cd	3.59	71.98 bc	-10.46	90.10 ab	6.75
ACPP (H5)	C1: $10^{-5}$	103.75 a	6.35	70,25cd	-12.58	93.20 ab	10.43
	C2: $10^{-7}$	102.17 bc	4.71	63.83 hi	-20.55	92.60 ab	9.72
	C3: $10^{-9}$	96.42e	-2.25	64.08 hi	-20.17	103.30 a	22.39
ACMA (H4)	C1: $10^{-5}$	98.08cd	0.51	63.31 hi	-21.30	93.30ab	10.55
	C2: $10^{-7}$	99.75 cd	2.25	70.71 de	-12.70	88.60 ab	4.98
	C3: $10^{-9}$	98.92 cd	1.33	66.70 fg	-16.94	88.10 ab	4.38
ACMPP (H7)	C1: $10^{-5}$	99.25cd	1.74	63.17 hi	-21.30	95.50 ab	13.15
	C2: $10^{-7}$	102.42 ab	4.92	60.58 hi	-24.53	97.07 ab	15.01
	C3: $10^{-9}$	96.92 de	-0.72	83.58 a	4.11	94.40 ab	11.85

<b>Newman-Keuls</b>	0.00	0.00	0.00
<b>P &lt; .05</b>			

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

was 16.70 cm or 65.35% was preceded by ACMPP  $10^{-9}$  M (18.5 cm or 83.17%). ACMA  $10^{-7}$  M had the lowest value (9.70 cm).

Comment [AM3]: Better the highest value first

Regarding NERICA 2, ACMA, 2.4-DCPAA and 2.5-DMPAA derivatives at all concentrations and ACPA  $10^{-5}$  M, showed regressive effects. ACMPP, ACPP and 2.4-DMPPA derivatives, had a positive effect. Among them, those improving this parameter the most were ACMPP  $10^{-5}$  M (12 cm or 34.83%) followed by ACMPP  $10^{-5}$  M and ACPP  $10^{-7}$  M with an average of 11.40 cm, increasing by a rate of 28.09%. 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 [21, 22, 23]. Similar results were obtained by [24] by because of increasing the girth of okra stems with auxin, and also by [25] by improving the diameter of xylem vessels of Populus using the growth regulator me. The inhibitory effect of 2.5-DMPAA and 2.4-DCPAA on the height of WAB638-1 and circumference of NERICA 2 as well as ACMA and ACPA  $10^{-5}$  M of the circumference of the latter variety would be related to a specific chemical toxicity. These results are in agreement with those of Baker and Weitzstein (2004) [26, 27] and Staswick et al. (2005) who reported that the toxicity was related to.

Comment [AM4]: Much better if you cite the authors too, like you did at the end of the paragraph

Comment [AM5]: ?

### 3.3 Vigor index

The average heights and neck girths measured for each treatment and variety were used to calculate

vigor indices (Table 3). They showed significant differences between treatments ( $P < 0.05$ ). The results reveal that the plants of the variety WAB638-1 treated with the derivatives ACMPP and 2.4-DMPP at  $10^{-7}$  M, gave the highest vigor indices. For these two treatments, the average value of the vigor index was 4.60 with the respective growth rates of 9.52% followed by the  $10^{-5}$  M ACMPP derivative (4.5 or 7.14%). The 2.5-DMPAA  $10^{-7}$  M with 4.10 obtained the lowest value statistically identical to the control.

At C26, plants treated with ACMPP  $10^{-9}$  M (4.40 or 10%) and 2.4-DMPPA  $10^{-5}$  M (4.30 or 7%) had the

highest vigor indices with identical influence. Their effect was followed by those of  $10^{-7}$  M ACPA and 2.4-DMPPA  $10^{-7}$  M and  $10^{-9}$  M concentrations with an average of 4.20 (5%). The treatments 2.5-DMPAA  $10^{-9}$  M, ACPP  $10^{-5}$  M and ACMA  $10^{-5}$  M, gave the lowest values with an average of 3.9.

For NERICA 2, plants sprayed with ACMA  $10^{-5}$  M and  $10^{-7}$  M had a lower vigor index than the control (2.90 and 3.10 or -12.12 and -6.06 %). In contrast, plants sprayed with ACMPP  $10^{-5}$  M (3.80 or 15.15 %) and  $10^{-7}$  M (3.70 or 12.20%) and CAPP  $10^{-5}$  M (3.80 or 15.15%) recorded the highest vigor indices with corresponding growth rates. 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 included in the synthesis of chlorophyll, which increased the photosynthetic efficiency and the manufacture of organic matter. Our results are close to those of [28]. The latter obtained an improvement in the vigor index of stigmas of a hybrid rice treated with gibberellin.

Comment [AM6]: Cite name authors

### 3.4 Number of stubs

The results for the activity of derivatives on tillers, reported in Table 4 show that the average numbers of tillers

were significant for all varieties. WAB638-1 plants had the highest numbers with 2.4-DMPAA  $10^{-5}$  M (14 Heels/footer 366.6%) followed by ACPP  $10^{-5}$  M (12 Heels/footer 300%) and ACMPP  $10^{-5}$  M and  $10^{-7}$  M (11 Heels/footer 266.6%). These treatments were not statistically different between them. The number of tillers produced by plants treated with the derivatives 2.5-DMPAA at the three concentrations, 2.4-DCPAA  $10^{-7}$  M and  $10^{-9}$  M, ACPP  $10^{-9}$  M, ACMA  $10^{-5}$  and  $10^{-7}$  M varied from

3 to 4 Heels/footer without difference with the control which also produced 3 Heels/footer. With the variety C6, all the derivatives favored tillering whatever the concentration compared to the control which produced 7 Heels/footer. However, the most favorable was 2.4-DMPAA  $10^{-7}$  M (19 Heels/footer equivalent to 171.4% compared to the control). The ACPP  $10^{-7}$  M derivative that follows it

Table 2. Effect of auxin derivatives on girth

Phenoxyacetic acid derivatives	Concentrations (M)	WAB638-1		C26		NERICA2	
		Circumference (cm)	AR (%)	Circumference (cm)	AR (%)	Circumference (cm)	AR (%)
Witnesses	C0: 0	10.70 fg	-	10.10 gh	-	8.90 cd	-
2,5-DMPAA (H3)	C1: $10^{-5}$	10.50 fg	-1.87	11.10 gh	9.90	6.80 ef	-23.60
	C2: $10^{-7}$	12.20 f	14.02	1150 gh	13.86	8.00 ef	-10.11
	C3: $10^{-9}$	11.70 fg	9.35	10.40 gh	2.97	6.00 ef	-32.58
2,4-DCPAA (H2)	C1: $10^{-5}$	11.80 fg	10.28	11.60 gh	14.85	6.00 ef	-32.58
	C2: $10^{-7}$	11.70 fg	9.35	11.70 gh	15.84	6.00 ef	-32.58
	C3: $10^{-9}$	11.90 fg	11.21	12.20 fg	20.79	6.90 ef	-22.47
2,4-DMPAA (H6)	C1: $10^{-5}$	15.20 cd	42.06	15.60 bc	54.46	10.60 bc	19.10
	C2: $10^{-7}$	18.10 b	69.16	14.20 cd	40.59	10.30 bc	15.73
	C3: $10^{-9}$	13.60 e	27.10	14.00 cd	38.61	8.70 cd	-2.24
ACPA (H1)	C1: $10^{-5}$	15.40 cd	43.93	12.20 fg	20.79	7.20 ef	-19.10
	C2: $10^{-7}$	15.00 cd	40.19	13.30 de	31.68	9.40 cd	5.62
	C3: $10^{-9}$	14.70 de	37.38	15.20 bc	50.50	8.70 cd	-2.25
ACPP (H5)	C1: $10^{-5}$	11.70 fg	9.35	13.00 ef	28.71	11.40 ab	28.09
	C2: $10^{-7}$	16.20 cd	51.40	16.70 b	65.35	10.40 bc	16.85
	C3: $10^{-9}$	10.50 fg	-1.87	10.20 gh	0.99	10.40 bc	16.85
ACMA (H4)	C1: $10^{-5}$	10.20 g	-4.67	11.60 gh	14.85	5.40 f	-39.33
	C2: $10^{-7}$	11.30 fg	5.61	9.70 h	-3.96	5.70 ef	-35.96
	C3: $10^{-9}$	11.50 fg	7.48	10.90 gh	7.92	7.10 ef	-20.22
ACMPP (H7)	C1: $10^{-5}$	16.60 c	55.14	13.20 ef	30.69	12.00 a	34.83
	C2: $10^{-7}$	19.30 a	80.37	12.10 gh	19.80	11.40 ab	28.09
	C3: $10^{-9}$	15.70 cd	46.73	18.50 a	83.17	10.10 cd	13.48
Newman-Keuls P < .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

increased tillering (17 Heels/footer or 142%).

At the level of NERICA 2 2.4-DCPAA  $10^{-5}$  M exerted an inhibitory effect on the production of tillers as well as ACMA  $10^{-7}$  M. The 2.5-DMPAA  $10^{-7}$  M and 2.5-DMPAA  $10^{-9}$  M treatments, on the one hand and ACPA  $10^{-7}$  M and ACPA  $10^{-9}$  M on the other hand with 5 tillers/plant were close to the control. ACPP  $10^{-5}$  M producing 15 tillers/plant and stimulating

Formatted: Highlight

tillering by 150% was more effective for this variety. Under  $10^{-7}$  M and  $10^{-9}$  M, ACMPP on the one hand and ACPP derivative, on the other hand and 2,4-DMPPA  $10^{-5}$  M and 2,4-DMPPA  $10^{-7}$  M treatments which produced 13, 11 and 12 Heels/foot respectively, were statistically identical. Their 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 favoured the differentiation of the buds, their bud break, and their emergence. Our results are in agreement with those of [29, 20, 30]. Indeed, the former obtained an increase in the number of tillers by foliar spraying of naphthalene acetic acid on rice. The latter showed that pretreatment of rice grains with indole butyric acid increased the number of tillers.

Comment [AM7]: Improve redaction

Comment [AM8]: Author cite

### 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.

Table 3. Influence of auxin derivatives on vigor index

Phenoxyacetic acid derivatives	Concentrations (M)	WAB638-1		C26		NERICA2	
		Strength index	AR (%)	Strength index	AR (%)	Strength index	AR (%)
Witnesses	C0: 0	4.20 de	-	4.0fg	-	3.30 cd	-
2,5-DMPAA (H3)	C1: $10^{-5}$	4.10 e	-2.38	4.00 fg	0.00	3.40 cd	3.03
	C2: $10^{-7}$	4.20 d	0.00	4.10 fg	2.50	3.20 cd	-3.03
	C3: $10^{-9}$	4.20 de	0.00	3.90 g	-2.50	3.20 cd	-3.03
2,4-DCPAA (H2)	C1: $10^{-5}$	4.20 d	0.00	4.00 fg	0.00	3.20 cd	-3.03
	C2: $10^{-7}$	4.20 de	0.00	4.00fg	0.00	3.20 cd	-3.03
	C3: $10^{-9}$	4.20 de	0.00	4.10 gf	2.50	3.40 cd	3.03
2,4-DMPPA (H6)	C1: $10^{-5}$	4.50 bc	7.14	4.30 a	7.50	3.60 ab	9.09
	C2: $10^{-7}$	4.60 a	9.52	4.20 c	5.00	3.60 bc	9.09
	C3: $10^{-9}$	4.40 c	4.76	4.20 c	5.00	3.20 cd	-3.03
ACPA (H1)	C1: $10^{-5}$	4.40 bc	4.76	4.10 ef	2.50	3.40 ad	3.03
	C2: $10^{-7}$	4.30 c	2.38	4.20 c	5.00	3.60 ab	9.09
	C3: $10^{-9}$	4.40 c	4.76	4.30 ab	7.50	3.40 ad	3.03
ACPP (H5)	C1: $10^{-5}$	4.20 de	0.00	4.10 cd	2.50	3.80 a	15.15
	C2: $10^{-7}$	4.50 b	7.14	4.30 a	7.50	3.60 ab	9.09
	C3: $10^{-9}$	4.10 de	-2.38	3.90 fg	-2.50	3.60 ab	9.09
ACMA (H4)	C1: $10^{-5}$	4.10 de	-2.38	4.00 fg	0.00	2.90 d	-12.12
	C2: $10^{-7}$	4.20 de	0.00	3.90 fg	-2.50	3.10 cd	-6.06
	C3: $10^{-9}$	4.20 de	0.00	4.00 fg	0.00	3.30 cd	0.00
ACMPP (H7)	C1: $10^{-5}$	4.50 b	7.14	4.10 de	2.50	3.80 a	15.15
	C2: $10^{-7}$	4.60 a	9.52	4.10 de	2.50	3.70 a	12.12
	C3: $10^{-9}$	4.40 bc	4.76	4.40 a	10.00	3.70 a	12.12
Newman-Keuls P < .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

These two axes express 96.93% (WAB638-1), 86.76% (C26) and 92.43% (NERICA 2) of the total variability (WAB638-1: figure 1, C26: figure 2, NERICA 2: figure 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.

In WAB638-1 all variables are positively correlated with the F1 axis. The 1st group (GI) is constituted by the treatments H3C1 (2.5-DMPAA  $10^{-5}$  M), H3C3 (2.5-DMPAA  $10^{-9}$  M), H2C3 (2.4-DCPAA  $10^{-9}$  M), H2C2 (2.4-DCPAA  $10^{-7}$  M), H2C1 (2.4-DCPAA  $10^{-5}$  M), H3C2 (2.5-DMPAA  $10^{-7}$  M), H4C1 (ACMA  $10^{-5}$  M), H4C2 (ACMA  $10^{-7}$  M), H4C3 (ACMA  $10^{-9}$  M), H5C3 (ACPP  $10^{-9}$  M), and H6C3 (2.4-DMPA ( $10^{-9}$  M), they had an effect close to the control. The 2nd group (GII) improving height included the H5C1 (CAPP  $10^{-5}$  M) treatments. Those in the 3rd group (GIII) formed by treatments H1C2 (ACPA ( $10^{-7}$  M), H1C3 (ACPA  $10^{-9}$  M), H1C1 (ACPA  $10^{-5}$  M), H7C3 (ACMPP  $10^{-9}$  M), H7C1 (ACMPP  $10^{-5}$  M), H7C2 (ACMPP  $10^{-7}$  M), H6C1 (2.4-DMPPA  $10^{-5}$  M), H5C2 (ACPP  $10^{-7}$  M), and H6C2 (2.4-DMPA ( $10^{-7}$  M) 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 H7C2 treatment (ACMPP  $10^{-7}$  M) which had the same effect as the TC0 control. Group II (GII) consists of treatments H3C2 (2.5-DMPAA  $10^{-7}$  M), H4C2 (ACMA  $10^{-7}$  M), H4C3 (ACMA  $10^{-9}$  M), H1C1 (ACPA  $10^{-5}$  M), H5C3 (ACPP  $10^{-9}$  M), H3C1 (2.5-DMPAA  $10^{-5}$  M), H4C1 (ACMA  $10^{-5}$  M), H2C3 (2.4-DCPAA  $10^{-9}$  M), H3C3

Table 4. Effect of auxin derivatives on the amount of tillers

Phenoxyacetic acid derivatives	Concentrations (M)	WAB638-1		C26		NERICA2	
		Heels/foot	AR (%)	Heels/foot	AR (%)	Heels/foot	AR (%)
Witnesses	C0: 0	3.00 e	-	7.00 i	-	6.00 bc	-
2,5-DMPAA (H3)	C1: $10^{-5}$	3.00 e	0.00	10.00 gh	42.70	6.00 bc	0.00
	C2: $10^{-7}$	3.00 e	0.00	9.00 gh	28.60	5.00 ac	-16.70
	C3: $10^{-9}$	3.00 e	0.00	10.00 gh	42.90	5.00 bc	-16.70
2,4-DCPAA (H2)	C1: $10^{-5}$	6.00 d	100.00	13.00 de	85.70	2.00 c	-66.70
	C2: $10^{-7}$	3.00 e	0.00	11.00 fg	57.10	6.00 bc	0.00
	C3: $10^{-9}$	4.00 e	33.30	11.00 f	57.10	6.00 bc	0.00
2,4-DMPPA (H6)	C1: $10^{-5}$	14.00 a	366.60	14.00 c	100.0	12.0 ab	100.00
	C2: $10^{-7}$	9.00 c	200.00	19.00 a	171.40	12.00 ab	100.00
	C3: $10^{-9}$	8.00 c	166.60	12.00 ef	71.40	10.00 b	66.70
ACPA (H1)	C1: $10^{-5}$	9.00 c	200.00	10.00 gh	42.90	5.00 bc	-16.70
	C2: $10^{-7}$	8.00 c	166.60	10.00 gh	42.90	6.00 bc	0.00
	C3: $10^{-9}$	10.00 c	233.30	14.00 cd	100.00	5.00 bc	-16.70
ACPP (H5)	C1: $10^{-5}$	8.00 c	166.60	15.00 c	114.30	15.00 a	150.00
	C2: $10^{-7}$	12.00 b	300.00	17.00 b	142.90	11.00 ab	83.3
	C3: $10^{-9}$	4.00 e	33.30	11.00 fg	57.10	11.00 ab	83.30
ACMA (H4)	C1: $10^{-5}$	4.00 e	33.30	10.00 gh	42.90	6.00 bc	0.00
	C2: $10^{-7}$	4.00 e	33.3	10.00 gh	42.90	5.00 bc	-16.66
	C3: $10^{-9}$	6.00 d	100.0	11.00 gh	57.10	6.00 bc	0.00
ACMPP (H7)	C1: $10^{-5}$	11.00 b	266.6	13.00 d	85.70	15.00 a	150.00
	C2: $10^{-7}$	11.00 b	266.60	13.00 d	85.70	13.00 ab	116.70
	C3: $10^{-9}$	9.00 c	200.00	11.00 f	57.10	13.00 ab	116.70
Newman-Keuls P < .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



H1C1, H1C2 and H1C3 : ACPA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H2C, H2C2 and H2C3 : 2,4-DCPAA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H3C1, H3C2 and H3C3 : 2,5-DMPAA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H4C1, H4C2 and H4C3 : ACMA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H5C1, H5C2, and H5C3 : ACPP ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H6C1, H6C2, H6C3 : 2,4-DMPPA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M) and H7C1, H7C2 et H7C3 : ACMPP ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M).

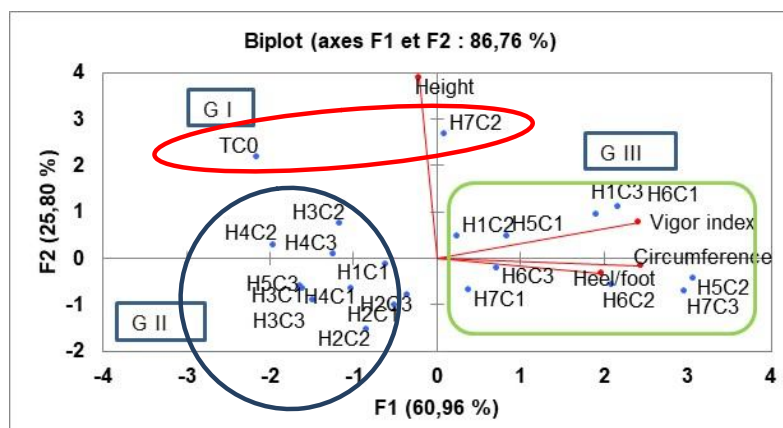


Figure 3. Representation of the C26 variety variables, derivatives and concentrations on the F1 and F2 axes using PCA

H1C1, H1C2 and H1C3 : ACPA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H2C, H2C2 and H2C3 : 2,4-DCPAA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H3C1, H3C2 and H3C3 : 2,5-DMPAA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H4C1, H4C2 and H4C3 : ACMA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H5C1, H5C2, and H5C3 : ACPP ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H6C1, H6C2, H6C3 : 2,4-DMPPA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M) and H7C1, H7C2 et H7C3 : ACMPP ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M).

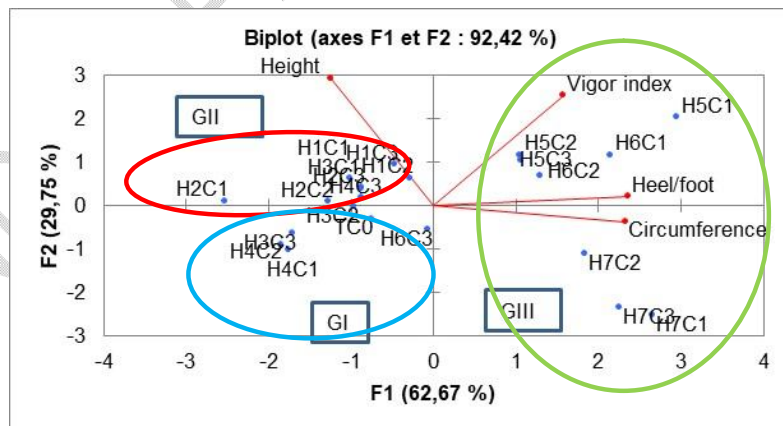


Figure 4. Representation of the C26 variety variables, derivatives and concentrations on the F1 and F2 axes using PCA

H1C1, H1C2 and H1C3 : ACPA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H2C, H2C2 and H2C3 : 2,4-DCPAA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H3C1, H3C2 and H3C3 : 2,5-DMPAA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H4C1, H4C2 and H4C3 : ACMA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H5C1, H5C2, and H5C3 : ACPP ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M), H6C1, H6C2, H6C3 : 2,4-DMPPA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M) and H7C1, H7C2 et H7C3 : ACMPP ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M).

M and  $10^{-9}$  M), H6C1, H6C2, H6C3 : 2,4-DMPPA ( $10^{-5}$  M,  $10^{-7}$  M and  $10^{-9}$  M) and H7C1, H7C2 et H7C3 : ACMPP ( $10^{-5}$  M,

#### 4. CONCLUSION

This study showed the real influence of some phenoxyacetic acid derivatives on the studied parameters. These effects varied according to the derivative, the concentration, the variety and the parameter. They were more important for the derivatives with propanoic chain. Those selected were ACPP, 2,4-DMPPA and ACMPP at concentrations  $10^{-5}$  M and  $10^{-7}$  M.

Comment [AM9]: How easy is it to acquire these types of compounds for farmers?

Formatted: Superscript

Formatted: Superscript

#### REFERENCES

1. Kouame K, Ake S, Yte W, Doumbia S, Konan K E, Kouassi N A, 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.
2. 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
3. Kouamé, Akpaud. Presentation on infrastructure and water control. 2018. Accessed March 5, 2022. Available: [https://riceforafrica.net/joomla/images/stories/PDF/gp\\_ci\\_fre2018](https://riceforafrica.net/joomla/images/stories/PDF/gp_ci_fre2018).
4. Gala Bi T J., Camara M, Yao-Kouamé, Keli Z J. Profitability of mineral fertilizer in rainfed rice cultivation: the case of the Gagnoa area in west-central Côte d'Ivoire. Journal of Applied Biosciences. 2011; (46): 3153-3162.
5. ONDR. National Rice Development Strategy 2012-2020. (2014). Accessed March 5, 2022. Available: [http://www.ondr.ci/infos\\_riz\\_systemes\\_production.php#:~:text=The%20yields%20are%20low%20around,represent%2080%25%20of%20the%20production](http://www.ondr.ci/infos_riz_systemes_production.php#:~:text=The%20yields%20are%20low%20around,represent%2080%25%20of%20the%20production).
6. Lee I J. Practical application of plant growth regulator on horticultural crops. J. Hort. Sci. 2003;(10): 211-217.
7. Basra A. Plant growth regulators in agriculture and horticulture: their role and commercial uses; CRC Press Inc: Boca Raton, FL, USA. 2000.
8. Davies P J. Plant hormones: physiology, biochemistry and molecular biology. Dordrecht: Springer Science & Business Media. 2013.
9. Kaya C, Kirmak H, Higgs D. Enhancement of growth and normal growth parameters by foliar application of potassium and phosphorus in tomato cultivars grown at high (NaCl) salinity. J Plant Nutr. 2001; (24): 357-367.
10. Sakuma S, Schnurbusch T. Of floral fortune: tinkering with the grain yield potential of cereal crops. New Phytologist. 2019; (225): 1873-1882.
11. Iqtidar H, Abdul A K, Imam B, Ejaz A K, 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.
12. 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).
13. Koffi J K, Dje B D P V, Vroh B T A, Kpangui K B, Adou Y C Y. 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.

Formatted: Font: Italic

14. 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.
15. 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.
16. Angladette A. Le riz. Maisonneuve et Larose. Paris, France. 1966.
17. Kouassi Y F, Gbogouri G A, N'guessan K. A, Bilgo A, Pascal K T, Angui, Ama T J. 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.
18. Kouakou K R. Evaluation of the productivity of two vivo methods (seedlings from stem fragments and propagation on of stem and multiplication on dehusled 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.
19. Amin AA, Gharib FA, Abouzienna HF, Dawood MG. Role of indole-3-butyric acid or/and of putrescine in improving productivity of chickpea (*Cicer arietinum* L.) plants. Pakistan Journal of Biological Sciences. 2013; (16):1894-1903.
20. 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.
21. Aloni R, Aloni E, Langhans M, Ullrich Cl. 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
22. Dubrovsky J G, Doerner P W, Colon-Carmona A, Rost L. Pericycle cell proliferation and lateral root initiation in Arabidopsis. Plant Physiology. 2000; (124) : 1648 - 1657.
23. 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.
24. 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.
25. 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.
26. Baker C M, Wetzstein H Y. Influence of auxin type and concentration on peanut somatic embryogenesis. Pl. Cell Tissue Organ Cult. 2004; 36 (3): 361 - 368.
27. 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.
28. Xiaomin W, Huabin Z, Qiyuan T, Wenwei M, Junjie M. Effects of Gibberellin acid application after Anthesis on Seed Vigor of Indica Hybrid Rice. Agronomy journal. 2019.
29. 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.
30. 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.
31. Thimann K V. Auxins. In: Wilkins, M. B., ed. Physiology of plant growth and development. London: McGraw-Hill. 1969; 1-45.
32. Turquin L.- Contribution to the study of the growth and development of b-type shoots in plantain

Formatted: Italian (Italy)

Formatted: Font: Italic

Formatted: Font: Italic

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.

UNDER PEER REVIEW