EFFECT OF PACLOBUTRAZOL AND KINETINS ON THE VEGETATIVE GROWTH, ROOT INITIATION AND TUBERIZATION OF *Manihot esculenta* Crantz

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Abstract
Field experiment was conducted to investigate the effect of application paclobutrazol (PBZ) and Kinetin at different concentration rates on growth, root initiation and tuberization of cassava grown under rainfed conditions. The experiment was set up as a 2x3x2 factorial in a complete randomized design with 3 replications. The first factor was the PGRs (Paclobutrazol and Kinetin) application, the second factor was varieties (TME419, IKWOCAS-LOCAL and UMUCASS 36) with the levels and third factor was the concentration (0, 100 and 200ppm). The uniform 25cm cassava stem cuttings obtained from the National Root Crops Research Institute and Ndufu Alike, Ikwo were soaked in the plant growth regulators for 30mins and allowed to dry at the different concentrations before the cuttings were thereby planted on the field. The plot area was $5m^2$ (1x5m) with inter and intra plot spacing of 1x1m between plots. Manual weeding was employed. From the result, the PBZ application reduced plants height and number of leaves, but tend to increase stem diameter while Kenitin application improved plant height and number of leaves, number of root, harvest Index and root weight, but reduced stem diameter of cassava as compared to untreated control. Kinetin application at 200ppm increased the storage root yield and vegetative growth by 53.08% and 52.61% respectively while PBZ application increased the storage root weight by 46.92% and had no effect on the vegetative growth. We recommend treatment combinations for future study on the root initiation, tuberization and shooting formation.

Keywords: Paclobutrazol, kinetins, vegetative growth, root initiation, tuberization.

Introduction

Cassava (*Manihot esculenta* Crantz) is cultivated mainly in the tropical and sub-tropical regions of the world, over a wide range of environmental and soil conditions. It is very tolerant of drought and heat stress and produces well on marginal soil. It is an important dietary staple in many countries, within the tropical regions of the world (Perez and Villamayor, 1984), where it provides food for more than 800 million people (FAO, 2007). As a subsistence crop, cassava is the third most important carbohydrate food source in the tropics after rice and maize, providing more than 60% of the daily calorific needs of the populations in tropical Africa and Central America (Nartey, 1978). A well planned strategy for the development and utilization of cassava and cassava products can provide incentives for farmers, crop vendors and food processors to increase their incomes. It can also provide food security for households producing and consuming cassava and cassava products (Plucknett *et al.,* 1998).

It is a crop that is generally grown on marginal lands with a minimum of agricultural inputs (Hillocks *et al.,* 2002). Once established, the cassava crop is given little attention, but still is able to tolerate weed competition, as well as insect, pest and disease. The potential exists for improving the productivity of cassava through better agronomic practices, superior varieties and pest and disease management.

Growth regulators play a key role for developing a specific mode of growth in the cultured cells or tissues, which may be due to accumulation of specific biochemical contents in them. The single or

combination of different hormones in the medium causes maintenance of specific and balanced inorganic and organic contents in the growing tissue. This leads the cells or tissues to develop either into shoots/or roots or even death (Ikram-ul-Haq and Dahot, 2007). Cytokinins such as benzyl aminopurine (BAP) and kinetin are known to reduce the apical meristem dominance and induce both auxiliary and adventitious shoot formation from meristematic explants in banana (Mok and Mok, 2001). However, the application of higher BAP concentrations inhibits elongation of adventitious meristems and the conversion into complete plants (Choi, *et al.,* 2010*)*. Interdependent role for growth regulators in the cassava tuberization has not been understudied comprehensively with the use of paclobutrazol and kinetin thus this study was undertaken to determine the effect of the PGRs on cassava root initiation and tuberization at 4 month after planting.

Materials and Methods

Research Site and Characteristics

The research was conducted at the Federal University Ndufu Alike Ikwo experimental site. The experiment was conducted in 2017 planting season from March to July. The experimental field was located at longitudes6° 44' East and latitude5° 28' North at an altitude of 252 meters above the sea level. The soil was loamy clay in texture having pH range of 4.5 to 5.7. The experimental area was under the subtropical wet monsoon climate, which is characterized by early and heavy rainfall during rainy season (March to September)

Experimental Design, Treatments and Planting material

The experiment was set up as a 2x3x2 factorial in a complete randomized design with 3 replications. The first factor was the PGRs (Paclobutrazol and Kinetin) application, the second factor was varieties (TME419, IKWOCAS-LOCAL and UMUCASS 36) with the levels and third factor was the concentration (0, 100 and 200ppm).

The uniform 25cm cassava stem cuttings obtained from the National Root Crops Research Institute and Ndufu Alike, Ikwo were soaked in the plant growth regulators for 30 mins and allowed to dry at the different concentrations before the cuttings were thereby planted on the field. The plot area was $5m^2$ (1x5m) with inter and intra plot spacing of 1x1m between plots. Manual weeding was employed.

(A) (B) (C) (D)

Plate 1: Picture showing (A) Cassava cuttings soaked in plant growth regulator (B) Hand weighing scale (C) Sensitive weighing balance (D) cassava roots being weighed on sensitive weighing balance

Data collection and analysis

Data were collected on the plant height (PH), leaf areas, shoot diameter, leaf number, root number (RN), root weight (RW), shoot weight, total weight and harvest index. Data collected were subjected to analysis of variance, genotype by environment interactions and correlation between growth and yield using GenSTAT statistical tool.

Results and Discussion

Field experiment was conducted at the experimental site of Federal University Ndufu-alike to check if the effect of kinetin and PBZ on cassava shooting showed significant influence on the root initiation and tuberization of different cassava varieties at their 4 month of development.

Paclobutrazol (PTZ) is a gibberellins inhibitor which usually have opposite and mutually antagonistic effects on plant growth and development (Balamani and Poovaiah 1985, Biddington *et al.,* 1992) while Kinetin (a cytokinin) a class of plant hormone that promotes cell division.

Result of PGR on the Vegetative growth characteristics of cassava varieties at 4MAP.

Effect of PGRs on Plant Height

Table 1 showed the effect of kinetin and Paclobutrazol (PBZ) on the vegetative growth of cassava varieties at 4MAP. The result of table revealed that kinetin and PBZ had no significant difference as they affect the plant height of the cassava genotypes across the concentrations when compared to the control. The table also showed that there was no interactive effect as all possible interaction showed no significant difference. Though, the PGRs application showed no significant difference in plant height of cassava at 4 weeks after planting (Table 1) when compared to the control, but the application of Kinetin gave a total mean value of 39.3cm which is higher than that of PBZ (35.4cm) at 4WAP. The reduced plant height caused by the PBZ is agreement with previous investigation by Zuo (2003), Yang and Cao (2011) and Medina *et al*. (2012). The plant height reduction was primarily due to internodes length shortening (Davis *et al*., 1991; Pinto *et al*., 2005).

Effect of PGR on branch height

Application of PBZ and kinetin caused no change on the branch height as compared to the control but there are genotype difference as TME419 (30.5cm) show the highest branch height, followed by the Local (26.2cm) and UMUCASS (16.9cm) has the least branch height. The interaction effect shows no significance in table 1. Though, the PGRs application showed no significant difference in branch height of cassava at 4 weeks after planting, when compared to the control, but there was a significant genotype differences among the varieties while kinetin gave the total mean of branch height with 27.0cm which is higher than that of PBZ (22.1cm) at 4WAP. The reduced plant height caused by the PBZ is agreement with previous investigation by Zuo (2003), Yang and Cao (2011) and Medina *et al*. (2012). The plant height reduction was primarily due to internodes length shortening (Davis *et al*., 1991; Pinto *et al*., 2005).

Effect of PGR on number of leaves

Application of PGR showed no significant effect on number of at four month after planting as compared to the control, also the interaction showed no significant effect on number of leaves as shown in table 1. Paclobutrazol applied at the cassava gave the lowest number of leaves at 4WAP. The result of the correlation (Table 3 and 4) also showed that Kinetin affected the positive correlation between plant height and number of root and root weight. This confirms the results reported in previous experiments with cassava (Gomathinayagam *et al*., 2007), potato (Tekalign and Hammes, 2004) and tomato (Berova and Slatev, 2000).

Effect of PGR on stem diameter

The result of the PGR as it affects stem diameter of the different genotypes of the cassava at four months after planting is shown in table 1, the result revealed that PBZ and Kinetin have different significant effect on stem diameter with kinetin showing the highest effect on stem diameter with the average stem diameter of (2.59cm) and the PBZ having (2.30cm). There was no genotype difference. The result of the table showed significant difference between the interaction of the concentration and genotype at 5% significant level with PBZ gave a higher significant stem diameter of 2.594cm than Kinetin with 2.304cm. Paclobutrazol application to the plants reduced in height was accompanied by significant stem thickening (Berova and Zlatev, 2000). In wheat, PBZ application increased thickness of the leaves by inducing additional layers of palisade mesophyll cells (Gao *et al*., 1987). In potato, PBZ application increased stem diameter due to induction of thicker cortex, larger vascular bundle and wider pith diameter (Tsegaw *et al*., 2005).

Results of PGR on the yield of cassava varieties at 4 month after planting

Effect of PGR on cassava root weight

The table 2 showed the effect of PGR on the yield of cassava varieties at four months after planting. The result of the table showed that there is no PGR effect on different genotype used at four months after planting as compared to the control but there was an interaction effect between concentration, genotype and PGR. Though, the PGRs application showed no significant difference on the fresh tuber yield of cassava at 4 weeks after planting, when compared to the control, but the effect of kinetin gave the total mean of fresh tuber weight of 1446g which is higher than the effect of PBZ (1278g) at 4WAP, which was highest at the concentration of 200ppm. This is in agreement with previous investigation reported by Yang and Cao (2011). The PBZ treatments considerably boosted tuber yield and this may be due to increased chlorophyll content and enhanced rate of net photosynthesis in potato plants (Tekalign and Hammes, 2004).

Effect of PGR on the harvest index

Table 2 also revealed the PGR effect as it affects the harvest index of cassava varieties at four months after planting which showed that there was no significant difference among genotype, PGR as compared to the control. The result also showed no significant across the interaction effect. This might be due to the earliness to evaluation, and better result should be observed when the tubers are fully expressed at the older age. Tekalign and Hammes, (2004) reported that there was an enhancing translocation of photosynthates to rapid tuber growth in PBZ treated plants in potato at late growth age.

Effect of PGR on the number of roots

Application of the PGR on the plant varieties in table 2 as it affects the number of root at four months after planting showed that the PGR has no significant effect on the cassava plant at four months after planting as compared to the control but there genotype effect with the Local showing the highest number of root (7.61) followed by the Umucass 37 (7.17) while TME419 showed the least no of roots with (6.94). The result shows an interaction effect between concentration and PGR, genotype and PGR, and also between concentration, genotype and PGRs. There was high significant ($P<0.001$) interaction between genotype and PGR. Which also in agreement with the findings of Tekalign and Hammes, (2004) who reported that there was an enhancing translocation of photosynthates to rapid tuber growth in PBZ treated plants in potato at late growth age.

Effect of PGR on biomass

The result of table 2 also showed the effect of kinetin and PTZ as it affects the biomass of the cassava varieties. The result showed at four month after planting there was no significant difference as the PGR affects the biomass among the genotypes as compared to the control. The result of the interaction showed that there was no interaction effect except interaction between genotype and PGR. The PBZ treatments considerably boosted tuber yield and this may be due to increased chlorophyll content and enhanced rate of net photosynthesis in potato plants (Tekalign and Hammes, 2004).

Result of the correlations

The result of the correlation table shown on Table 3 and 4 showed that PBZ application had a negative significant decreased on shooting of the cassava plant but reduced stem do not have negative effect on the yield development while Kinetin application showed a positive significant increased on shooting and showed no difference from the yield of PBZ at 4mont after planting. The reduced plant height caused by the PBZ is agreement with previous investigation by Zuo (2003), Yang and Cao (2011) and Medina *et al*. (2012). The plant height reduction was primarily due to internodes length shortening (Davis *et al*., 1991; Pinto *et al*., 2005).

Table 1: Effect of PGR on the vegetative growth characteristics of cassava varieties at 4 Month after planting

Treatment	Plant Height (cm)	Branch Height (cm)	No. of Leaves	Stem Diameter (cm)
Genotype (Gen)				
UMUCASS	33.2	16.9	39.2	2.461
TME419	42.3	30.5	36.3	2.542
Local	36.6	26.2	42.6	2.344
FLSD	7.79	7.90	8.47	0.349
PGR				
Kinetin	39.3	27.0	40.4	2.304
Paclobutrazol	35.4	22.1	38.4	2.594
FLSD	6.36	6.45	6.91	0.285
Concentration (ppm)				
0 (Control)	36.2	23.4	38.4	2.400
100	35.6	28.9	39.4	2.362
200	40.3	21.4	40.3	2.586
FLSD	7.79	7.90	8.47	0.349
F-TEST				
Gen	ns	*	ns	ns
PGR	ns	ns	ns	*
Conc	ns	ns	ns	ns
Conc×Gen	ns	ns	ns	*
Conc×PGR	ns	ns	ns	ns
Gen×PGR	ns	ns	ns	ns
Conc×Gen×PGR	ns	ns	ns	ns

*ns = not significance, *, ** and *** means significant at 10%, 5% and 1%.*

Table 2: Effect of PGR on the yield of cassava varieties at 4 Month after planting

Treatment	Root Weight/plant (g)	Harvest Index	No. of Root	Biomass (g)
Gen				
UMUCASS	1281	0.533	7.17	1114
TME419	1363	0.521	6.94	1149
Local	1441	0.556	7.61	1188
FLSD	231.9	0.074	0.995	256.2
PGR				
Kinetin	1446	0.546	7.44	1182
Paclobutrazol	1278	0.528	7.04	1119
FLSD	189.3	0.060	0.812	209.2
Concentration (ppm)				
0	1371	0.553	8.06	1126
100	1263	0.521	6.17	1063
200	1452	0.537	7.50	1262
FLSD	231.9	0.074	0.995	256.2
F-test				
Gen	ns	ns	**	ns
PGR	ns	ns	ns	ns
Conc	ns	ns	ns	ns
Conc×Gen	ns	ns	ns	ns
Conc×PGR	ns	ns	*	ns
Gen×PGR	ns	ns	***	*
Conc×Gen×PGR	***	ns	*	ns

*ns = not significance, *, ** and *** means significant at 10%, 5% and 1%.*

Table 3: Correlation between the growth and yield characteristics as it is affect by PBZ

	Biomass	Branch Height	Harvest Index	No. of Leaf	No. of Root	Plant Height	Root weight	Stem diameter
Biomass	1.00							
Branch Height	-0.555	1.00						
Harvest Index	-0.833**	0.346	1.00					
No. of Leaf	-0.297	0.008	0.749*	1.00				
No. of Root	0.297	-0.714*	0.064	0.508	1.00			
Plant Height	-0.428	0.470	0.694*	**0.846****	0.211	1.00		
Root weight	0.176	-0.377	0.396	**0.828****	0.547	0.476	1.00	
Stem diameter	0.398	-0.248	-0.042	0.582	0.756*	0.545	0.567	1.00

Table 4: Correlation between the growth and yield characteristics as it is affect by Kinetin

	Biomass	Branch Height	Harvest Index	No. of Leaves	No. of Root	Plant Height	Root weight	Stem diameter
Biomass	1.00							
Branch Height	0.721*	1.00						
Harvest Index	**-0.829****	**-0.841****	1.00					
No. of Leaves	0.281	0.485	-0.122	1.00				
No. of Root	0.475	0.370	-0.514	0.215	1.00			
Plant Height	0.453	0.092	-0.339	0.198	**0.772***	1.00		
Root weight	0.640*	0.532	-0.428	0.357	0.555	0.584	1.00	
Stem diameter	0.659*	0.212	-0.415	0.323	0.130	0.559	0.278	1.00

Conclusion

Application of PBZ and Kinetin has no pronounced significant effect on growth and yield content as compared to no application control. However, Kinetin application increased the storage root yield by 53.08% while PBZ application increased the storage root weight by 46.92%. Also Kinetin application increased the growth of the cassava by 52.61% while PBZ application increased by 47.39%. In conclusion there were no serious significant changes at 4 month of planting caused by the application of the treatments but 200ppm concentration of Kinetin application gave a slightly increased vegetative growth and also had the best effect on yield development of the cassava at 4MAP. From the findings of this study, the following recommendations are made for future research on effect of PGRs on the tuberization and shooting of cassava plants.

- The treatment combination is a good suggestion for better improvement for tuberization and shooting formation.

- Extension of time of evaluation should be encouraged to see the effect of these PGRs at older age.
- Spraying should also be included in the method treatment applications with a wider range of concentrations.

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