The Impact of Hormone Concentration, Clone Type and Corm Size on *in situ* Sucker Development of Enset (*Ensete ventricosum*) at Basketo, Southern Ethiopia

METAFERIA MULUNEH BANTAYEHU[1*], RORO GOBENA AMSALU[2], DESSA ALEMU[3]

[1]M.Sc. (Horticulture) Department of Horticulture; Jinka University, Jinka, ETHIOPIA
[2]Assistant Professor of Physiology, Horticulture; Hawassa University, Hawassa, ETHIOPIA
[3]Assistant Professor of Physiology, Horticulture; Dilla University, Dilla, ETHIOPIA

Abstract: *Enset is not just a food crop, but is a multipurpose crop of which every part of the plant (except the root) is utilized, for food and several non-food applications. Conventionally enset is propagated by vegetative means from underground rhizome/corm. In vitro enset multiplied from any part of plant by the use plant growth regulating hormones. However, hormone application is not commonly utilized on in situ enset propagation. Therefore, this study was designed to study the impact of hormone concentration on corm size and different accession on in situ sucker multiplication. An experiment was conducted in factorial arrangement using RCBD with sixteen treatments each replicated three times. The treatment consisted of four NAA+BAP mg/l combined concentration (0.75 NAA+2.25 BAP, 1.5 NAA+4.5 BAP, 3.0 NAA+9.0 BAP and 0 NAA+0 BAP mg/l) two clones (*"kaati ziinik" and "ziinik buukuma"*) and two corm sizes (whole corm and halved corm). Data related to sucker multiplication and sucker growth parameters collected during the experiment period. Clone* kaati ziinik *couple with whole corm size gave the maximum sucker than halved corm. However, clone "*ziinik buukuma*" produced vigorous and larger number of sucker from halved corms than using whole corm. The interaction of hormone concentration, clone and corm size was significantly influenced number of sucker, number of root; leaf area index and sucker dry weight. The maximum number of sucker and leaf area index were recorded from whole corm of clone KZ treated with NAA/2.25 BAP mg/l hormone concentrations. In general, it was observed that the highest number of root was recorded by halved and whole corm of clone KZ treated with 1.5 NAA + 4.5 BAP mg/l and 3.0 NAA + 9.0 BAP mg/l combined concentration, respectively. The highest developed dry weight of sucker was scored from whole corm of clone KZ treated with 1.5 NAA + 4.5 BAP mg/l combined concentration. The finding of this study provides an evidence for the application of plant growth regulating hormones on in situ multiplication of Enset from corm. In general, to use 1.5 NAA + 4.5BAP mg/l combined concentration on clone ZB with halved corm is recommended. It was observed comparatively the high number of emerged sucker, leaf area index number of root and minimizes cost of corm.*

Key words: *hormones combination*, "kaati ziinik", "ziinik buukuma", *in situ propagation*

1. Introduction

Enset (*Ensete ventricosum* (Welw) Cheesman) is multi-purpose crop in Ethiopia. The country has been identified as the center of origin and diversity of enset (Fekadu, 1996). Enset belongs to a family *Musaceae*, which is a perennial, herbaceous and long broad leaves. In Ethiopia enset is grown and distributed at altitudes between 1600 and 3000 m.a.s.l. areas with an average annual rainfall of 1100 to 1500 mm (Tsehaye and Kebebew, 2006). The crop is widely grown in home gardens of Central, South and Southwestern part of Ethiopia, but frequent droughts have led to the expansion of enset cultivation to other parts of the country (Zerihun *et al*., 2013).

Enset is crop with great economic and cultural importance in Ethiopia, which is widely used for many different purposes, including food, forage, medicine, building material and fiber (Struik, 2016). This crop contributes to food security (a traditional staple food

crop) for more than 20% of Ethiopia's population (Ayele and Omprakash, 2014). Fresh enset plant parts are used as fodder for domestic animals during dry season and some enset clones are reported to have medicinal value to human beings and domestic animals (Temesgen *et al.*, 2014).

Enset conventionally propagated by vegetative means while the plant is in its vegetative phase, before the inflorescence begins elongating from the base of the pseudostem. Commonly whole corm is planted or it is longitudinally split into two or four parts through the apex and each part is planted separately (Belhu *et al.*, 1994; Mulugeta *et al.*, 2002). Conventional enset multiplication has been facing a number of constraints: low multiplication rate, the average number of suckers per corm per year is not more than 10/15 suckers and number of enset suckers was affected by size of corms or corm pieces used (Mulugeta *et al*., 1996; Taye *et al*., 2016).

Plant propagation *in vitro* can be achieved by zygotic embryo culture, organogenesis, or somatic embryogenesis (Mulugeta and Staden, 2004). Various combinations of nutrients, plant growth regulators and environmental factors for different species or genotypes may stimulate the micro-propagation of plants. Manipulation of these factors may enable plant breeders and propagators to control plant cell morphogenesis and to develop reliable cell to plant regeneration systems (Mulugeta and Staden, 2004). Plant growth regulating hormones (auxins andcytokinins) affect *in vitro* enset multiplication through stimulating cell division and controlling cell differentiation and morphogenesis (Collin and Edwards, 1998). With the application of biotechnological tools *in vitro* propagation of enset was shown to have a significant importance and applications to conserve germ-plasm and propagation of virus free plantlets (Kassahun *et al*., 2016).

Despite to importance's, *in vitro* propagation also facing constraints, which was reported by many researchers: Bezuneh, (1980); Diro and Van Staden, (2004) noted that micro-propagation of enset plants is prone to various problems, blackening of explants, formation of unwanted callus and a low rate of multiplication. Also enset clones and part of explants was varied with its response to level and type of growth regulating hormones (Almaz *et al*., 2000; Genene and Firew, 2016). Therefore, to view *in situ* effect of plant growth regulating hormones in enset corm propagation is necessary. Thus, aim of this study was to evaluate the effect of hormone concentration, clone type, and corm size on in situ sucker development and to see alternative propagation method of enset (*Ensete ventricosum*) in Basketo Special District at Southern Ethiopia.

2. Material and Methods

The trial was conducted in the South Nations, Nationalities and People's Regional State, at Basketo Special District of Ethiopia (06^0 18' N, 36^0 37' E; 1872 m.a.s.l) from December 2019 to March 2020. The soil at the site of experiment is a silt loam on the top35cm of soil. According to data recorded by instrument "*testo*" (174H, Testo AG, Germany) the experiment site have maximum 28.4 ^{0}C and minimum 14.4 ^{0}C mean day temperature and 63.56 % mean relative humidity at a time of experiment.

The experiment was conducted in factorial arrangement using RCBD with three replications. The study consists of four levels combined auxin (NAA - naphthalene acetic acid), and cytokinin (BAP - benzyl amino purine): 0 NAA + 0 BAP mg/l, 0.75 NAA + 2.25 BAP mg/l, 1.5 NAA + 4.5 BAP mg/l, and 3.0 NAA + 9.0 BAP mg/l hormone concentration, with following recommendation of Genene and Firew, (2016). For each clones under this experiment, there were 8 treatments applied On 32 whole and half sized corms, total 96 corms and corm pieces of each clones.

Collected planting material was exposed to direct sun light for one day, next day hormone combinations were prepared. Dipping of whole and halved corms of clones under hormones concentration for five minute was done. The corms and corm pieces were planted in a bad, with 1m distance in and between rows. The field was irrigated manually and cultivated in 20 days interval. The effect of hormone concentration, clone type and corm size was observed after 100 days from planting of corms and corm pieces. All data were analyzed using SAS statistical software version 9.0 (SAS Institution, 2002). Mean separation was done by using Tukey's procedure ($p < 0.05$). When there was a statistically significant interaction between the factors, the interaction was considered, rather than the main effect, otherwise only the main effect of treatment was presented.

3. Result and Discussion

Number of Sucker

Data analysis result indicated that interaction of hormone concentration with clone type and corm size was significantly affected on *in situ* propagation of enset. The interaction of hormone concentration with clone type and corm size were significantly ($p \leq 0.05$)

influenced number of sucker, leaf area index, number of root and sucker dry weight. However, day to regenerate, percent of regeneration, height of sucker, pseudostem height and other growth parameters were not significantly ($p>0.05$) influenced by interaction of hormone concentration with clone type and corm size (Appendix table1).

It was observed that the highest number of sucker (56.92) was recorded from interaction of whole corm of clone *kaati ziinik* 0.75 NAA + 2.25 BAP mg/l concentrations. The follow number of sucker (46.50 and 45.92) was recorded from interaction of whole corm of control/untreated with clone *kaati ziinik* and *ziinik buukuma*, respectively. The lowest number of sucker (4.42) was recorded from interaction of halved corm of clone *kaati ziinik* with 0.75 NAA + 2.25 BAP mg/l concentrations (Table 1).

Number of sucker was significantly increase due to interaction of 0.75 NAA + 2.25 BAP mg/l concentration with clone *kaati ziinik* of whole corm size by 10.42, 33.09, 11, and 32.59 rather than suckers grown from interaction of untreated (control) with whole corm of *kaati ziinik*, halved corm of *kaati ziinik*, whole corm of *ziinik buukuma*, and halved corm of *ziinik buukuma*. Whereas, due to interaction of clone *ziinik buukuma* with halve sized corm and 3.0 NAA + 9.0 BAP mg/l concentration was significantly increased number of sucker by 11.33, 28.92, and 22.42 as compared to interaction of 3.0 NAA + 9.0 BAP mg/l concentration with whole corm of clone *kaati ziinik*, halve sized corm of clone *kaati ziinik*, and whole corm of clone *ziinik buukuma*, respectively. However, increasing combined concentration from 0.75 NAA + 2.25 BAP mg/l enhanced apical dominance on some whole corms of clone *kaati ziinik* and *ziinik buukuma*.

Generally, it was observed those clones were varied with their response to level of hormones combination with a difference of corm size. The result of this study agree with the finding of Almaz *et al*., (2000); Mulugeta and Staden, (2004) who's reported that *in vitro* multiplication of enset using of cytokinins revealed in minimum level of multiple shoot formation due to a monopodial corm morphology and complete apical dominance.

Table 1 Interaction effect of hormones concentration, clone and corm size on number of sucker, leaf area index, number of root and developed sucker dry weight (g).

Interactions of factors			Number	Leaf area	Number	Sucker dry
Hormones(mg/l)	***Clone***	***Corm size***	**of Sucker**	**index**	**of root**	**weight (g)**
0 NAA +0BAP	*Kaati ziinik*	Full	46.50^{ab}	1.36^{ab}	36.33^{abc}	35.77^{ab}
0.75 NAA +2.25BAP	*Kaati ziinik*	Full	56.92^{a}	1.60^{a}	40.33^{ab}	48.95^{ab}
1.5 NAA + 4.5 BAP	*Kaati ziinik*	Full	43.00^{ab}	1.12^{abcd}	44.00^{a}	58.07^{a}
3.0 NAA + 9.0 BAP	*Kaati ziinik*	Full	30.33^{abc}	0.95^{abcde}	46.33^{a}	40.22^{ab}
0 NAA + 0 BAP	*Kaati ziinik*	Half	23.83^{abc}	0.340^{bcde}	14.00^{c}	11.40^{ab}
0.75 NAA + 2.25 BAP	*Kaati ziinik*	Half	4.42^{c}	0.016^{e}	13.33^{c}	1.50^{b}
1.5 NAA + 4.5 BAP	*Kaati ziinik*	Half	4.75^{c}	0.040^{e}	46.83^{a}	3.64^{b}
3.0 NAA + 9.0 BAP	*Kaati ziinik*	Half	13.92^{bc}	0.130^{de}	18.17^{bc}	8.06^{ab}
0 NAA + 0 BAP	*Ziinik buukuma*	Full	45.92^{ab}	1.294^{abc}	17.67^{bc}	51.76^{ab}
0.75 NAA + 2.25 BAP	*Ziinik buukuma*	Full	30.42^{abc}	0.639^{abcde}	23.00^{abc}	20.45^{ab}
1.5 NAA + 4.5 BAP	*Ziinik buukuma*	Full	18.33^{bc}	0.584^{abcde}	30.00^{abc}	26.75^{ab}
3.0 NAA + 9.0 BAP	*Ziinik buukuma*	Full	19.75^{bc}	0.383^{bcde}	41.33^{ab}	29.43^{ab}
0 NAA + 0 BAP	*Ziinik buukuma*	Half	40.17^{abc}	0.690^{abcde}	12.00^{c}	42.24^{ab}
0.75 NAA +2.25BAP	*Ziinik buukuma*	Half	24.33^{abc}	0.254^{cde}	12.67^{c}	19.00^{ab}
1.5 NAA +4.5 BAP	*Ziinik buukuma*	Half	41.75^{ab}	1.240^{abc}	23.67^{abc}	32.19^{ab}
3.0 NAA +9.0 BAP	*Ziinik buukuma*	Half	42.17^{ab}	1.117^{abcd}	24.67^{abc}	38.54^{ab}
LSD (0.05) probability based on Tukey's test			53.20	1.64	25.51	53.41
MSE			308.72	0.29	71.01	311.14
CV (%)			28.89	36.83	15.17	30.16

(Means with the same letters are not significant different)

Leaf Area Index

It was observed that interaction of hormone concentration with clone and corm size had significantly influenced leaf area index (Appendix table 1). The highest leaf area index (1.60) was recorded from interaction whole corm of *kaati ziinik* with 0.75 NAA + 2.25 BAP mg/l concentrations. Follow leaf area index (1.36) was recorded from interactions of whole corm of clone *kaati ziinik* with control (untreated). The lowest leaf area index (0.016) was recorded from interactions of halved corm of clone *kaati ziinik* with 0.75 NAA + 2.25 BAP mg/l combined concentration. Due to interaction of clone *kaati ziinik* with whole corm and 0.75 NAA + 2.25 BAP mg/l concentration leaf area index was significantly increased by 1.584, 0.961 and 1.346 rather than from interaction of 0.75 NAA + 2.25 BAP mg/l concentration with halve sized corm of clone *kaati ziinik*, whole corm of clone *ziinik buukuma* and halve sized corm of clone *ziinik buukuma*, respectively (Table 1).

Number of Root

Data analysis result indicated that interaction of hormone concentration with clone type and corm size had significantly ($p \leq 0.05$) affected number of root (Appendix table 1). The highest root numbers (46.83 and 46.33) was recorded from interaction of *kaati ziinik* with halves sized corm and 1.5 NAA+ 4.5 BAP mg/l concentration and clone *kaati ziinik* whole corm and 3.0 NAA + 9.0 BAP mg/l concentration. Follow number of root (44.00) was recorded from interactions of clone *kaati ziinik* with whole corm and 1.5 NAA + 4.5 BAP mg/l combined concentration. The lowest numbers of root (12.00) was recorded from interactions of clone *ziinik buukuma* with halved corm and control/untreated concentration.

The result of three factors interaction revealed that effect of hormone concentration significantly varied on *kaati ziinik* with a difference of planted corm size. However, the mean number of root by *ziinik buukuma* tends to increase with increasing combined hormone concentration on both whole and halved corms. The result of this investigation contract with the finding of Genene and Firew, (2016) reported that the effect of auxin and cytokinin combination on *in vitro* regeneration that enset clones are varied on their response in number of root by combined hormones level.

Developed Sucker Dry Weight

Also, it was observed that interaction of hormone concentration with clone type and corm size significantly ($p \leq 0.05$) influenced developed sucker dry weight (Appendix table 1). The highest (58.07g) developed sucker dry weight was recorded from interaction of clone *kaati ziinik* with whole corm and 1.5 NAA + 4.5 BAP mg/l concentration. The follow (51.76 g and 48.95 g) developed sucker dry weights was recorded from interactions of clones *ziinik buukuma* and *kaati ziinik* with whole corm of control/untreated and 0.75 NAA + 2.25 BAP mg/l concentrations, respectively. The minimum (1.50 g) developed sucker dry weight was recorded from interactions of clone *kaati ziinik* with halved corm and 0.75 NAA + 2.25 BAP mg/l combined concentration. Due to interaction of 1.5 NAA + 4.5 BAP mg/l combined concentration with clone *kaati ziinik* of whole corm significantly increased developed sucker dry weight by 54.43g and 31.32g as compared to developed sucker dry weight recorded from interaction of 1.5 NAA + 4.5 BAP mg/l with halve sized corm of clone *kaati ziinik* and whole corm of clone *ziinik buukuma* respectively. The correlation analysis revealed that developed sucker fresh weight with developed sucker dry weight were significantly at ($p<0.01$) and positively ($R^2=0.944$) correlated. From the weight recorded, dry weight can be measured for the reason that of close relation between fresh and dry weight (Karlsson *et al*., 2015).

Days to 50% Emergency

Statistical analysis result indicated that interaction of hormone concentration and clone type significantly ($p \leq 0.05$) influenced day to 50% emergence. However, day to regenerate, number of sucker, percent of regeneration, height of sucker, pseudostem height, pseudostem circumference, leaf length and other growth parameters were not significantly influenced by interaction of combined hormone concentration and clone type (Appendix table 2).

The result to some extent agrees with the finding of Ali, (2014); Reshma *et al*., (2017) who's reported that the effect of plant regulators on growth parameter of *Gladiolus* varied with varietal difference was observed. The highest day to 50% sucker emergence (80.14) was recorded from interaction of clone *kaati ziinik* with 3.0 NAA +

BAP mg/l combined concentration. Follow day to 50% emergence (77.71 and 77.38) was recorded from interaction of clone *ziinik buukuma* and clone *kaati ziinik* with 0.75 NAA + 2.25 BAP and 1.5 NAA + 4.5 BAP mg/l hormones concentration, respectively. The lowest day to 50% emergence (52.52) was recorded from interaction of clone *ziinik buukuma* with 3.0 NAA + 9.0 BAP mg/l concentration. It is observed that interaction of clone *ziinik buukuma* with 3.0 NAA + 9.0 BAP mg/l hormones concentration significantly minimize by 27.64 day to 50% sucker emergence as compared to interaction of clone *kaati ziinik* with3.0NAA+9.0 BAP mg/l hormones concentration

The result of this study revealed that *ziinik buukuma* was significantly influenced by combined hormone concentration. It is tends to decrease day to 50% emergence with increasing hormone concentration. The result of study to some extent agrees with finding Almaz *et al*., (2000); Mulugeta, (2003); Genene and Firew, (2016) who's reported that cultivars are varied with their response to level and combination of hormones. The correlation analysis revealed that day to 50% emergence with leaf mass ratio was significant at ($p < 0.01$) and positively (R^2=0.752) correlated.

Data analysis result revealed that interaction of clone type and corm size had significant effect on on propagation of enset at field condition. It is observed that shoot length, number of leaves per sucker, specific leaf area and developed sucker fresh weigh were significantly ($p \leq 0.05$) influenced with interaction of clone type and corm size. However, number of day to regenerate, percent of regeneration and other growth parameters were not significantly affected with interaction (Appendix table 3). The result obtained in this investigation agrees with the finding of Belhu *et al*., (1994); Mulugeta *et al*., (2002); Memon *et al*.,(2009); Taye *et al*., (2016) who's studied the growth parameters of emerged sucker were significantly influenced with the variations of clone/cultivar and corm size.

Height of Sucker

It was observed that highest height of sucker (43.95 cm and 41.03 cm) was recorded from whole corm of clone *kaati ziinik* and clone *ziinik buukuma*, respectively. The follow height of sucker (33.78 cm) was recorded from interaction of clone *ziinik buukuma* with halve sized corm. The minimum height of sucker (15.27 cm) was recorded from halved corm of clone *kaati ziinik*. Sucker grown from whole corm of clone *kaati ziinik* had significantly increase height of sucker by 28.68 cm than sucker grown from halved corm of clone *kaati ziinik.*

Table 2 Interaction effect of hormone concentration and clone type on percent of regeneration and day to 50% emergence.

Interaction of factors		***Percent of regeneration***	***Day to 50% emergence***
Clone	**Hormone concentration (mg/l)**		
Kaati ziinik	0 NAA + 0 BAP	50.00	69.92^{ab}
Kaati ziinik	0.75 NAA + 2.25 BAP	54.17	62.29^{ab}
Kaati ziinik	1.5 NAA + 4.5 BAP	54.17	77.38^{a}
Kaati ziinik	3.0 NAA + 9.0 BAP	75.00	80.14^{a}
Ziinik buukuma	0 NAA + 0 BAP	79.17	72.21^{ab}
Ziinik buukuma	0.75 NAA + 2.25 BAP	62.50	77.71^{a}
Ziinik buukuma	1.5 NAA + 4.5 BAP	66.67	71.54^{ab}
Ziinik buukuma	3.0 NAA + 9.0 BAP	70.83	52.50^{b}
LSD (0.05) probability based on Tukey's test		NS	30.90
MSE		747.53	280.42
CV (%)		21.34	11.94

(Means with the same letters are not significantly different.)

Number of Leaves per Sucker

Statistical analysis result revealed that interaction of clone type and corm size significantly ($p \leq 0.05$) influenced number of leaves per sucker (Appendix table3). It was observed that the highest number of leaves per plant (4.13 and 3.92) was recorded from interaction of whole corm with clones *kaati ziinik* and *ziinik buukuma*, respectively. Follow number of leaves per sucker (3.02) was recorded from interaction of clone *ziinik buukuma* having halved corm. The lowest number of leaves per sucker (1.75) was recorded from interaction of clone *kaati ziinik* having halves corm. In this study clone *kaati ziinik* having whole corm size significantly increase number of leaves per sucker by 2.38 than sucker grown from halved corms of *kaati ziinik* and also planting of halved corm of clone *ziinik buukuma* was increased number of leaves by 1.27 rather than halved corm of *kaati ziinik*.

This difference in number of leaves per sucker might be because of the variation of height of sucker with a difference of clone and corm size. The result of this study was disagree with Abraham, (2018) reported geno types (Terch X, Tercha Y and Ferezye) having halved corm, number of leaves per plant was not significantly varied. The correlation analysis revealed that number of leaves per plant with pseudostem circumference and leaf length significantly ($p<0.01$) and positively ($R^2=0.865$ and $R^2=0.918$) respectively, correlated.

Table 3 Interaction effect of clone type with corm size on growth parameter of sucker

Interaction of factors		*Number of leaves*	*Specific leaf area (m^2/g)*	*Developed Sucker fresh weight (g)*
Clone	**Corm size**			
Kaati ziinik	*Full*	4.13^{a}	0.0033^{b}	480.67^{a}
Kaati ziinik	*Half*	1.75^{b}	0.0039^{ab}	87.10^{b}
Ziinik buukuma	*Full*	3.92^{a}	0.0063^{a}	353.96^{a}
Ziinik buukuma	*Half*	3.02^{a}	0.0033^{b}	380.77^{a}
LSD (0.05) based on Tukey's test		1.26	0.0025	211.51
MSE		1.32	0.000005	37436.8
CV (%)		17.93	27.05	29.71

(Means with the same letters are not significantly different)

Developed Sucker Fresh Weight

It was also observed that interaction of clone type and corm size had significantly ($p \leq 0.01$) influenced developed sucker fresh weight (Appendix table 3). The highest developed sucker fresh weight (480.67 g) was recorded from interaction of whole corm clone *kaati ziinik*. The follow developed sucker fresh weights (380.77 g and 353.96 g) were recorded from interaction of clone *ziinik buukuma* having halved and whole corm sized, respectively. The lowest developed sucker fresh weight (87.10 g) was recorded from interaction halved corm of clone *kaati ziinik*. It was observed that using of whole corm of *kaati ziinik*as planting material significantly increases developed sucker fresh weight by 397.57 g than using of halve sized corm of clone *kaati ziinik*. However, there is no significant difference between halved and whole corm of clone *ziinik buukuma* (Table 3). This might be because the variation of number sucker and height of sucker between planted clones and corm sizes.

Therefore, it would be the recommendations touse halve sized corm of clone *ziinik buukuma* and whole corm of clone *kaati ziinik*.

4. Conclusion and Recommendation

To evade related problems in conventional way propagation, to develop an alternative way of propagation is crucial. This experiment was conducted to view the effect of NAA + BAP concentration with four level on *in situ* propagation of enset with varying of clone and corm size.

The finding of study indicated that interaction of hormone concentration with clone type was significantly influenced growth parameters of

enset sucker. Interaction of 3.0 NAA + 9.0 BAP mg/l with clone *ziinik buukuma* significantly minimized day to 50% sucker emergence. It would be beneficial to test the effectiveness of using of hormones with varying of clones.

Similarly, interaction of combined hormone concentration with clone type and corm size was revealed significant variation on sucker growth parameter; Whole corm of clone *kaati ziinik* couple with 0.75 NAA + 2.25 BAP mg/l was significantly increased number of sucker and leaf area index. But, number of root and developed sucker dry weight significantly increased by interaction 1.5 NAA + 4.5 BAP mg/l, with whole corm of clone *kaati ziinik*. However, halved corm of clone *ziinik buukuma* interaction with 1.5 NAA + 4.5 BAP mg/l and 3.0 NAA + 9.0 BAP comparatively performed the highest value of growth parameters. This implies that using of hormone combinations on *in situ* enset propagation is necessary. It would be good to continue working with varying concentration and types of hormones, enset clone and corm size at field condition

Therefore, 1.5 NAA + 4.5 BAP mg/l interactions with clone *ziinik buukuma* and halved corm, records the highest values for most growth parameters. It is recommended for maximum number of sucker and economically minimizes planting material quantity *in situ* propagation of enset. Because of high rotting tendency of halve sized corm of clone *kaati ziinik*, it is recommended to use whole corm

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Appendix Table 1 ANOVA table of growth parameters for treatments interaction clone type with corm size and hormones concentration.

Source of Variation	DF	Sum square	Mean Square	F – Value	Pr> F
Days to regenerate	10	3452.98	345.30	1.49	0.1871
Number of sucker	10	7742.35	774.24	2.51	0.0236
Days to 50% emergence	10	4495.05	449.51	1.52	0.1781
Percent of regeneration	10	9609.38	960.94	1.45	0.2051
Sucker length	10	3011.54	301.15	2.10	0.0547
Pseudostem length	10	12.66	1.27	0.78	0.6446
Pseudostem circumference	10	31.49	3.15	0.99	0.4689
Leaf number per plant	10	14.17	1.42	0.98	0.4827
Leaf length	10	932.76	93.28	1.07	0.4148
Leaf width	10	92.48	9.25	0.69	0.7221
Leaf area	10	4865.77	486.58	0.80	0.6313
Leaf area index	10	7.98	0.79	2.73	0.0151
Specific leaf area	10	0.000094	0.0000094	1.97	0.0718
Leaf mass ratio	10	0.17	0.017	1.56	0.1654
Number of root	10	1871.42	187.14	2.64	0.0182
Root length	10	536.75	53.68	1.20	0.3303
Developed suckers Fresh weight	10	743709.32	74370.93	1.80	0.1008
Developed suckers dry weight	10	7586.88	758.69	2.44	0.0272

Appendix Table 2 ANOVA table of growth parameters for treatments interaction of hormone concentration with clone type.

Source of Variation	DF	Sum square	Mean Square	F – Value	Pr> F
Days to regenerate	3	1701.30	567.10	2.20	0.1028
Number of sucker	3	279.09	93.03	0.20	0.8891
Days to 50% emergence	3	2936.60	978.87	3.49	0.0243
Percent of regeneration	3	1705.73	568.58	0. 67	0.5744
Sucker length	3	683.18	227.73	0.84	0.4780
Pseudostem length	3	3.87	1.29	0.65	0.5875
Pseudostem circumference	3	4.38	1.46	0.34	0.7985
Leaf number per plant	3	1.80	0.60	0.26	0.8514
Leaf length	3	135.29	45.10	0.32	0.8083
Leaf width	3	31.92	10.64	0. 58	0.6311
Leaf area	3	1080.34	360.11	0.60	0.6189
Leaf area index	3	0.84	0.28	0.57	0.6377
Specific leaf area	3	0.000018	0.0000062	1.01	0.3989
Leaf mass ratio	3	0.066	0.022	1.80	0.1619
Number of root	3	565.02	188.34	1.26	0.3026
Root length	3	92.68	30.87	0.53	0.6645
Developed suckers Fresh weight	3	60259.90	20086.63	0.33	0.8011

Appendix Table 3 ANOVA table of growth parameters for treatments interaction of clone type with corm size.

Source of Variation	DF	Sum square	Mean Square	F – Value	Pr> F
Days to regenerate	1	51.09	51.09	0.19	0.6620
Number of sucker	1	5032.76	5032.76	16.39	0.0002
Days to 50% emergence	1	6.31	6.31	0.02	0.8924
Percent of regeneration	1	325.52	325.52	0.44	0.5122
Sucker length	1	1376.34	1376.34	9.06	0.0045
Pseudostem length	1	1.10	1.10	0.71	0.4030
Pseudostem circumference	1	0.55	0.55	0.17	0.6819
Leaf number per plant	1	6.56	6.56	4.98	0.0312
Leaf length	1	322.04	322.04	3.87	0.0558
Leaf width	1	10.72	10.72	0.87	0.3576
Leaf area	1	287.63	287.63	0.48	0.4931
Leaf area index	1	4.50	4.50	14.37	0.0005
Specific leaf area	1	0.000038	0.000038	7.53	0.0090
Leaf mass ratio	1	0.0033	0.0033	0.26	0.6156
Number of root	1	238.52	238.52	2.50	0.1212
Root length	1	96.33	96.33	2.10	0.1545
Developed suckers Fresh weight	1	530145.42	530145.42	14.16	0.0005
Developed suckers dry weight	1	4919.74	4919.74	15.98	0.0003

Appendix Table 4 ANOVA table of growth parameters for treatments interaction of hormone concentration with corm size.

Source of Variation	DF	Sum square	Mean Square	F – Value	Pr> F
Days to regenerate	3	493.32	164.44	0. 63	0.5995
Number of sucker	3	1649.65	549.88	1.35	0.2710
Days to 50% emergence	3	436.74	145.58	0.42	0.7364
Percent of regeneration	3	3164.06	1054.69	1.44	0.2451
Sucker length	3	757.60	252.53	1.33	0.2770
Pseudostem length	3	2.60	0.87	0.55	0.6503
Pseudostem circumference	3	11.40	3.80	1.10	0.3601
Leaf number per plant	3	4.55	1.52	1.02	0.3943
Leaf length	3	310.67	103.56	1.16	0.3356
Leaf width	3	31.86	10.62	0.80	0.5022
Leaf area	3	2022.18	674.06	1.12	0.3526
Leaf area index	3	1.88	0.63	1.61	0.2021
Specific leaf area	3	0.000021	0.0000069	1.13	0.3475
Leaf mass ratio	3	0.0335	0.0112	0.89	0.4521
Number of root	3	727.52	242.51	2.18	0.1055
Root length	3	128.21	42.74	0.91	0.4426
Developed suckers Fresh weight	3	12704.34	4234.78	0.08	0.9709
Developed suckers dry weight	3	358.36	119.45	0.27	0.8467
Developed suckers dry weight	3	1510.40	503.47	0.98	0.4113