Original article

Effect of cultivar, parent corm pre-treatment and sucker size on enset (*Ensete ventricosum*, Musaceae) growth

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Summary

In Ethiopia, enset (*Ensete ventricosum*, Musaceae) has been utilized as multipurpose crop since ancient time, being a measure for smallholder farmers to mitigate prolonged droughts and thus climate change effects. However, there is little research on enset agriculture to provide appropriate advice to farmers. Enset management relies on farmers' indigenous knowledge, which shall be acknowledged, but must be tested and evaluated. Poor management practises are identified as a cause for low productivity. To test the effect of parent corm pre-treatment, cultivar and initial sucker size on further growth and development, 162 suckers from the six released enset cultivars ('Endale', 'Gewada', 'Kelisa', 'Mesena', 'Yanbule', and 'Zerita') were detached from parent corms and planted individually. Plant characteristics were recorded at planting and at yearly destructive sampling for three years, and after cutting off at soil surface at two years and allowing regrowth during additional two years. At all occasions, development of different characteristics depended on sucker size at planting. Cultivars differed by their inherent characteristics throughout the study, while propagation method had no effect on further growth. The results underline the importance of more research on improving the techniques of vegetative reproduction. Achieving large suckers at propagation has long-term benefits to the success in enset agriculture. The technical knowledge on planting material achieved in this study can directly be disseminated through agricultural extension and adopted by current enset farmers as well as new growers.

Keywords
climate change mitigation, drought tolerance, Ethiopia, food security, indigenous crop, sustainable agriculture

Significance of this study

What is already known on this subject?

- Enset is a valuable traditional food security crop for mitigating and adapting to climate change. Research-based advice is needed to improve production management.

What are the new findings?

- Size of planted sprouts determined plant size of all recorded characteristics (corm, pseudostem, leaf size) for years of growth, even when cut off and allowed to regrow.

What is the expected impact on horticulture?

- Improving advice to farmers enhances enset management. Research on propagation, to achieve generally larger sprouts, will favour efficient enset agriculture.

Introduction

Enset, [*Ensete ventricosum* (Welw.) Cheesman], Musaceae, has been utilised as a crop in Ethiopia since ancient time. Enset as a species, as other Musaceae crops, is perceived as a horticultural crop while enset in cultivation systems is referred by the more general 'enset agriculture' (*e.g.*, Shack, 1963). Enset agriculture contributes to retain soil fertility (Tensaye *et al.*, 1998; Blomme *et al.*, 2008; Zewdie *et al.*, 2008). Among tropical forests and agroforestry, it is one of the most efficient systems for carbon sequestration (Negash and Starr, 2015). Individual plants are harvested after about 3-6 years of growth (Pijls *et al.*, 1995), therefore, as any perennial crop; enset prevents erosion and keeps soil moisture.

Enset is known as a drought-tolerant crop; it is said that enset-growing farmers never starved during the famines in east Africa in the 1970s and 1980s (Brandt *et al.*, 1997). In Ethiopia, enset agriculture has for long proven as farmers' adaptation strategy to climate change effects. As food resource, enset nutritive values are similar to potato (Mohammed *et al.*, 2013). A common food product, *kocho*, is fermented and long-term storable without cooling equipment (Bosha *et al.*, 2016). In addition, enset gives the highest yield in terms of edible energy per area and time unit of crops grown in Ethiopia (Tsegaye and Struik, 2001). It is a multipurpose crop: pseudostem and corm are used for food production, leaves and pseudostem for fibres and wrapping material, all parts and residues are suitable animal fodder, and there are landraces used for traditional medicines (Tsegaye and Struik, 2001; Tsehaye and Kebebew, 2006; Nyunja *et al.*, 2009; Funte *et al.*, 2010; Mohammed *et al.*, 2013).

Enset agriculture has obviously a wide range of economic, social and environmental benefits. Propagation, management and food processing techniques rely on farmers' indigenous knowledge. Indigenous technical knowledge should be acknowledged, for example to mitigate climate change

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effects by maintaining and developing local agriculture and forestry (IPCC, 2014). Thus, it is necessary to support farmers with research and extension efforts to maximise the benefits from enset agriculture. However, there are currently few research results to rely on. For example, there are only 166 original articles that include 'enset' or '*Ensete*', from any aspect, in 'Web of Knowledge' during the last 40 years, and advice to farmers must be based on serious studies and recorded plant performances.

Main factors identified to negatively influence enset production are drought, diseases, shift to other crops, small land holding, population pressure, high consumption rate, low soil fertility, poor management practices, mole rats, and hunger (Tenaye and Geta, 2009). These challenges and constraints in the production can be met by interventions which can contribute to improving knowledge base and practices of enset management. For example, the plant disease 'bacterial wilt', caused by *Xanthomonas campestris* pv. *musacearum* and serious to enset and other Musaceae, is often mentioned as an obstacle for the development of enset agriculture, but it can efficiently be prevented by using clean tools and not carelessly sharing tools or distributing plant material (Tripathi *et al*., 2009; Addis *et al*., 2010; Blomme *et al*., 2014). Generally, it is important to evaluate traditional methods, because even if a method functions, its procedures are not systematically tested and proven for being the best possible practice (Karlsson *et al*., 2015).

Traditionally, farmers propagate enset vegetatively by removing the apical meristem from a parent corm and bury it, entirely or in smaller parts, in the field. That propagation method gives, depending on cultivar and technique, about 30–100 new sprouts per parent corm (Karlsson *et al*., 2015). Similar macropropagation in the field is identified as a cost-efficient propagation method for banana (Ntamwira *et al*., 2017). After planting enset sprouts individually, it is common to transplant one or more times before harvest. Two transplantations are reported to be superior to one or three, explained as two transplantations prolonging the maturity period, giving larger plants and higher yield (Tsegaye and Struik, 2001). However, the initial sprout size was not reported, and to our knowledge, there is no report on individual plant performance after detaching suckers from parent corm. Sucker sizes differ substantially within the group from each buried corm but also between multiplications occasions (Diro *et al*., 2003; Karlsson *et al*., 2015). This study aimed at providing technical knowledge on the effect of enset sprouts' size on further growth by recording plant size increase in the consecutive years after detaching from parent corm and planting in the field.

Materials and methods

In November 2011, sprouts of the six released enset cultivars ('Endale', 'Gewada', 'Kelisa', 'Mesena', 'Yanbule', and 'Zerita' [Yeshitila *et al*., 2011]) were planted in an open field (25 × 25 m), surrounded by a 1.5 m metal mesh fence and a ditch, at Wolaita Sodo University (06°50'00"N, 37°45'07"E, 1,882 m a.s.l.), Ethiopia. The sprouts originated from 54 parent corms that were pre-treated in three different ways (*i.e*., apical meristem removed and either *i* left entire, *ii* split in two pieces, or *iii* split in four pieces) before being buried for sucker production in January 2011. In May 2011, suckers had emerged from all parent corms. In November 2011, parent corms were uprooted and suckers were detached and individually recorded (Karlsson *et al*., 2015). Three sprouts from each parent corm were planted individually: 6 cultivars × 3 parent corm pre-treatments × 3 replicating parent corms × 3 sprouts = 162 sprouts planted. From each parent corm, the sprouts were randomly allocated to destructive sampling after one, two or three years of growth. Additional sprouts were planted, surrounding the research sprouts, to avoid edge effects. During the study, carefully cleaned tools were used, and the tools were used only in the research field.

When parent corms were buried for sucker production, 15 L 50/50 mix of softened local soil and dry cow manure (soil and manure characteristics: Karlsson *et al*., 2015) was applied to each burial hole. No additional fertiliser was applied when planting the 162 sprouts. Holes with circa 40 cm diameter and 50 cm depth were dug in triangular pattern around previous holes for corm burial. The planting holes were refilled with about 10 cm softened top-soil before sucker was placed therein and remaining soil added. After watering with circa 5 L per sprout after planting, the sprouts were subjected to natural weather conditions (recorded by the National Meteorology Agency of Ethiopia, Figure 1). During the study period, all plant residues (old leaves and harvested plant material) were used as mulch and distributed evenly beneath the plants in the research plot.

The sprouts to be planted were individually recorded for number of fully developed green leaves, blade width and blade length of the longest fully developed leaf, pseudostem height (height from soil level to the point where the leaf stalk of the lowest green leaf began to detach from pseudostem), pseudostem circumference at the base and mid of pseudostem, and corm height and circumference. After one, two,

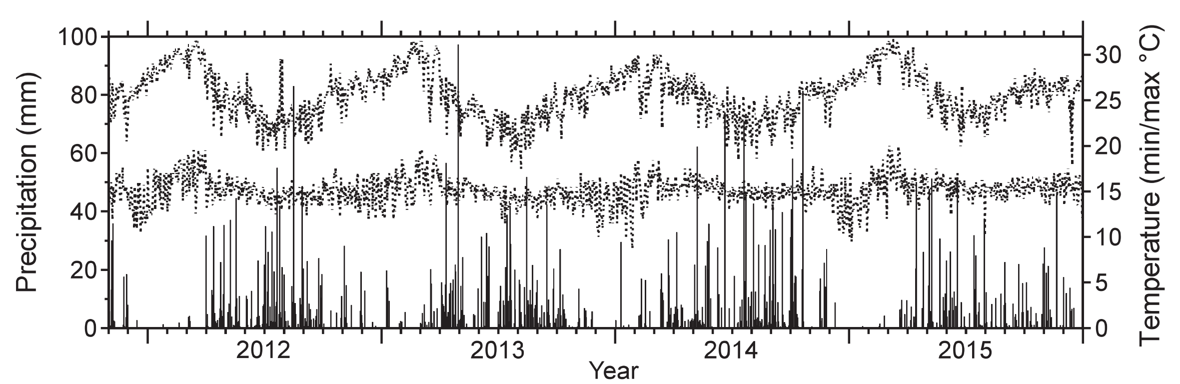

Figure 1. Daily weather during growth of *Ensete ventricosum* sprouts at Wolaita Sodo University campus, Ethiopia. Data recorded by National Meteorology Agency of Ethiopia.

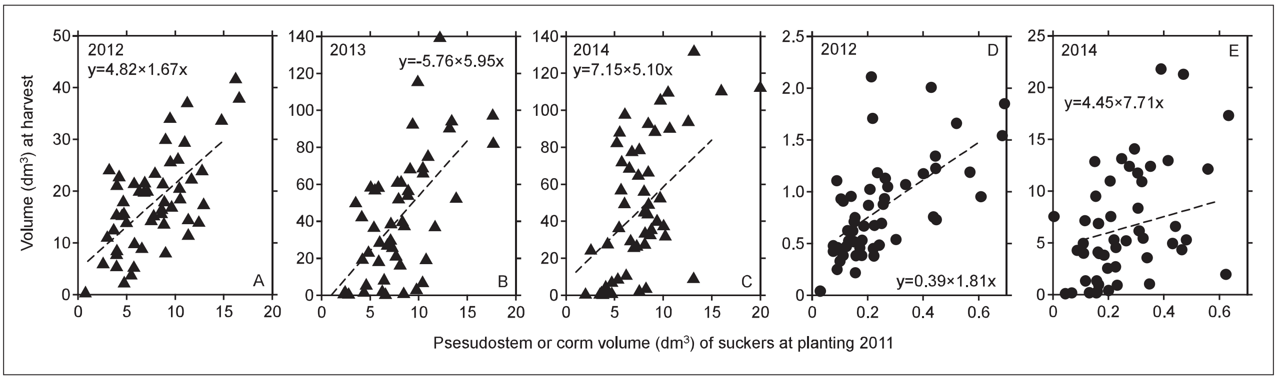

FIGURE 2. Volume of pseudostem (A–C) and corm (D, E) of individuals of *Ensete ventricosum* (Musaceae) at planting of suckers, newly detached from parent corm, and at harvest after one, two or three years of growth in open field, subjected to natural conditions only, in southern Ethiopia. Correlation lines are shown; see Table 2 for R^2 and p-values. Observe different scales on y-axes.

three and four years of growth, pseudostem was recorded as at planting on all plants in the research plot. After one, two and three years of growth the plants allocated to destructive sampling were harvested and leaves were recorded as at planting. The plants harvested 2012 and 2014 were dug up and the corm recorded as at planting. In addition, fresh weight was recorded for the plants harvested 2012. In 2013, after two years of growth, the plants allocated to destructive sampling had aboveground parts cut off and the corm left in the soil, allowing regrowth for two years, until 2015. From the recorded data, volumes of pseudostem and corm, and blade area, were calculated (following Karlsson *et al.*, 2015).

Corm and pseudostem volume of planted sprouts ($N = 162$) were analysed with ANOVA for the independent factors cultivar and parent corm pre-treatment. For plants grown for 1–3 years ($N = 54$ year^{-1}), responses to the independent factors cultivar, parent corm pre-treatment and time were analysed with ANOVA. Response variables were corm volume, pseudostem volume and yearly growth rate (pseudostem volume increase during the final year before each harvest). Growth rate before and regrowth rate after harvest of aboveground biomass ($N = 54$), was analysed by first performing linear regression on pseudostem volume, for each plant, during each two-years period of growth and then using the achieved factors of inclination (*i.e.*, the "b" in "$a = bx + c$") as response variable to the independent factors cultivar and time in ANOVA. Analyses were followed by Tukey HSD test for significant independent factors. Relation between (1) plant fresh weight and size records and (2) size records at planting and at harvest were analysed with linear regression on data of each individual plant. For green leaves, the average number at each point in time was calculated. Statistical analyses were performed with Statistica 13 (Dell, Inc., 2015).

Results

Corm volume of planted suckers (Figure 2; min–max 0.03–0.69, average 0.26, sd 0.22 dm^3) did not differ significantly among cultivars or parent corm pre-treatments (Table 1). Planted suckers had pseudostem volumes of 0.54–21.48 dm^3 (Figure 2; average 7.58, sd 3.59). At planting, average pseudostem volume differed among cultivars ('Endale' being smallest, Table 2, Figure 3) but not among parent corm pre-treatment (Table 1). At planting, average number of fully developed green leaves were 5.2 (sd 1.4), and after one, two and three years there were on average 6.5 (sd 1.4), 4.5 (sd 1.4) and 6.0 (sd 1.6) leaves per plant. Of 162 planted sprouts, nine (5.6%) died (two 'Endale', one 'Gewada', two 'Kelisa', three 'Mesena', one 'Zerita') before the intended harvest time. These plants were excluded from calculations. No sign of plant disease was observed within the research plot.

Parent corm pre-treatment had no significant effect on corm or pseudostem volume at harvest (Table 1). Pseudostem and corm volume at harvest increased significantly with time (Tables 1 and 2, Figures 3A, C). The factor cultivar had no effect on corm volume (Table 1). Pseudostem volume

TABLE 1. ANOVA results (F-value and p-value notation: *** = $p \leq 0.001$, ** = $p \leq 0.01$, * = $p \leq 0.05$, ^{ns} = $p > 0.05$) from enset (*Ensete ventricosum*) planted suckers and further plant growth. Corm harvest was done one and three years after planting, harvest of pseudostem one, two and three years after planting. Growth rate was recorded as volume change during the year before harvest. Regrowth was analysed from increase of pseudostem volume from planting and during two years of undisturbed growth when aboveground parts were cut off compared to two years of regrowth thereafter (*cf.* Figure 3B).

Factor	Corm volume			Pseudostem volume					
	df	Planting	Harvest	df	Planting	Harvest	Growth rate	df	Regrowth
		F^p	F^p		F^p	F^p	F^p		F^p
Cultivar	5	1.65^{ns}	0.69^{ns}	5	3.65**	3.46**	2.88*	5	3.12*
Parent corm pre-treatment[a]	2	2.48^{ns}	0.69^{ns}	2	0.50^{ns}	1.69^{ns}	0.50^{ns}	NA	NA
Time	1	NA	56.19***	2	NA	15.93***	25.73***	1	0.67^{ns}
C × T	5	NA	0.36^{ns}	10	NA	0.82^{ns}	2.27*	5	0.24^{ns}

[a] Parent corms of suckers were pre-treated in three different ways (*i.e.*, apical meristem removed and either *i* left entire, *ii* split in two pieces, or *iii* split in four pieces) before buried for multiplication (Karlsson *et al.*, 2015).

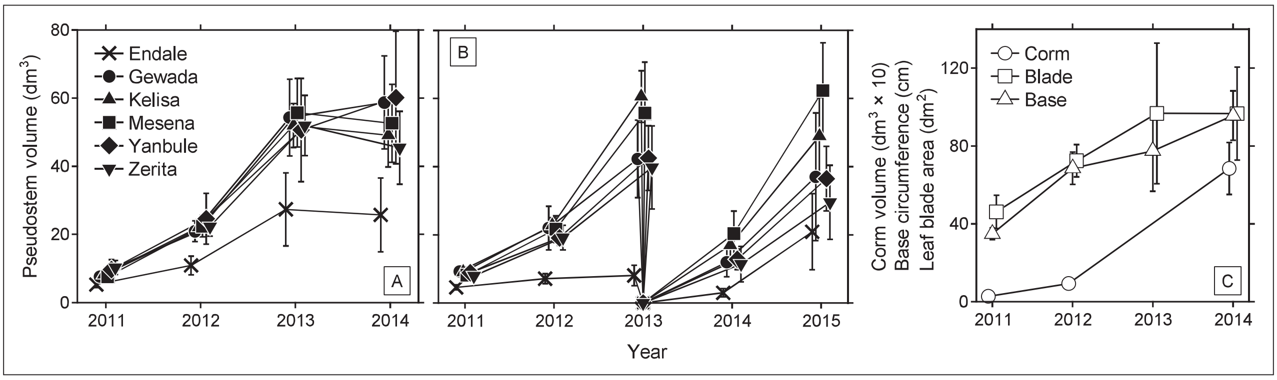

FIGURE 3. Sizes (average ± sd) of plant characteristics of six cultivars of *Ensete ventricosum* (Musaceae) at planting of suckers 2011 and during continued growth (A and B: cultivar average, $N = 9$ plants; B had pseudostem cut off 2013) and from destructive sampling (C: overall average, $N = 6$ cultivars).

was dependent on cultivar (Table 1); 'Endale' was smallest and the only cultivar significantly different from any other (Table 2, Figures 3A, B).

Parent corm pre-treatment had no significant effect on pseudostem growth rate (Table 1). Pseudostem growth rate differed significantly between time periods and was dependent on cultivar (Table 1). The highest pseudostem growth rate occurred the second year after planting and the lowest the third year (Table 2). Among cultivars, 'Mesena' and 'Yanbule' grew faster than 'Endale' (Table 2, Figure 3A). Pseudostem volume increase during two years before and two years after cutting off aboveground biomass did not differ significantly (Table 1, Figure 3B), while the cultivars 'Kelisa' and 'Mesena' had significantly higher growth rate than 'Endale' (Tables 1 and 2). Base circumference and leaf blade size increased with time (Table 1, Figure 3C).

Plant weight was correlated to different size measurements; best fit of linear regression to total plant weight had pseudostem volume and base circumference (Table 3). Volumes of pseudostem and corm of suckers, newly detached from parent corms, were significant predictors of analogous volumes up to three years after planting (Table 3, Figure 2). Pseudostem base circumference and area of leaf blade of the longest leaf of planted suckers were significant predictors of analogous sizes in the future (Table 3). Pseudostem volume of planted suckers was significant predictor for the future volume when plants were cut off at soil surface two years after planting and after regrowth for additional two years (Table 3).

There was no significant interaction between the factors time and cultivar for corm or pseudostem volume, nor for regrowth rate (Table 1). For growth rate during undisturbed growth the interaction between cultivar and time was significant (Table 1): compared to the other cultivars, pseudostem volume increase of cultivar 'Endale' was less pronounced during the second year of growth.

Discussion

The good establishment of plants in the field during natural weather conditions (Figure 1) shows how well suited enset is to be utilized as crop in the prevailing climate in southern Ethiopia: planted suckers, with 90–95% water con-

TABLE 2. Significant ($p < 0.05$) differences (Tukey HSD test following ANOVA) between six cultivars ('Endale', 'Gewada', 'Kelisa', 'Mesena', 'Yanbule', and 'Zerita') of *Ensete ventricosum* and time periods (grown for three years after planting of newly detached suckers, except regrowth treatment that was conducted two plus two years). Plants were grown in open field in southern Ethiopia.

Recorded characteristic and occasion		Significant factor from ANOVA	Significant differences (Tukey HSD test)
Corm size	Harvest	Time	1st year < 3rd year ($p < 0.001$)
Pseudostem size	Planting	Cultivar	'Endale' < 'Yanbule' ($p = 0.002$)
			'Endale' < 'Zerita' ($p = 0.005$)
	Harvest	Cultivar	'Endale' < 'Gewada' ($p = 0.038$)
			'Endale' < 'Mesena' ($p = 0.012$)
			'Endale' < 'Yanbule' ($p = 0.026$)
		Time	1st year < 2nd year ($p < 0.001$)
			1st year < 3rd year ($p < 0.001$)
	Growth rate	Cultivar	'Endale' < 'Mesena' ($p = 0.026$)
			'Endale' < 'Yanbule' ($p = 0.040$)
		Time	0–1 year < 1–2 year ($p < 0.001$)
			0–1 year > 2–3 year ($p = 0.004$)
			1–2 year > 2–3 year ($p < 0.001$)
	Regrowth	Cultivar	'Endale' < 'Kelisa' ($p = 0.029$)
			'Endale' < 'Mesena' ($p = 0.009$)

Table 3. Linear regression of different characteristics (Factor I and Factor II) when enset (*Ensete ventricosum*) of six different cultivars were grown in open field in southern Ethiopia. Suckers were planted in 2011, and destructive sampling was done every year for three years.

Factor I	Factor II	R^2	p
Plant fresh weight 2012	Pseudostem height 2012	0.094	0.027
	Pseudostem mid circumference 2012	0.677	<0.001
	Pseudostem base circumference 2012	0.852	<0.001
	Pseudostem volume 2012	0.798	<0.001
Pseudostem volume 2011[a]	Pseudostem volume 2012	0.425	<0.001
	Pseudostem volume 2013	0.376	<0.001
	Pseudostem volume 2014	0.410	<0.001
	Pseudostem volume 2015[b]	0.222	<0.001
Leaf area 2011[a]	Leaf area 2012	0.194	0.001
	Leaf area 2013	0.297	<0.001
	Leaf area 2014	0.290	<0.001
Base circumference 2011[a]	Base circumference 2012	0.430	<0.001
	Base circumference 2013	0.303	<0.001
	Base circumference 2014	0.394	<0.001
Corm volume 2011[a]	Corm volume 2012	0.378	<0.001
	Corm volume 2014	0.184	0.002

[a] Records of sizes of suckers when detached from parent corms.
[b] Plants had pseudostem cut off at soil surface in 2013 and regrew thereafter.

tent (Karlsson *et al.*, 2015), survived the drought and grew efficiently during the main rainy period in June–August (Figures 1 and 3). The planted suckers showed strong growth the first two years, but the growth rate decreased from year 1–2 to year 2–3 (Table 2), which may be partly a result of no additional fertilisation since parent corm burial and partly a sign of the plants being relatively close to developing flower stalks. Farmyard manure is shown to improve chemical and physical soil characteristics of environments similar to the research plot (Bayu *et al.*, 2006). It remains to be investigated in detail if any certain fertiliser component limits the growth of enset in various environments. However, the propagation technique with circa 7.5 L of pulverised dry cow manure provided together with the parent corm in the burial hole (Karlsson *et al.*, 2015; Bosha *et al.*, 2019) is a recommendation that can be adopted by farmers directly. The sprout planting method used in this study, with relatively deep hole and softened top soil, is promising as there was only little mortality (5.6% during the study period). The utilisation of the plant residues within the plot as mulch follows farmers' tradition. For banana (a close relative to enset) mulching pseudostems and leaves is shown to be especially beneficial for potassium recycling (Lekasi *et al.*, 1999). Farmers are recommended to use mulch from own residues of healthy plants to prevent spread of plant diseases (Addis *et al.*, 2010).

There are suggestions of developing micropropagation of enset, in order to conserve genotypes, or enhance production, using laboratory techniques similarly to banana commercial vegetative production (Negash *et al.*, 2000; Birmeta and Welander, 2004). With current rapidly increasing demand for food, feed and fiber, enset agriculture is a good candidate for advancement at a large plantation level. In that regard, it is important to consider plantlet size when planting in the field, because the typical *Musa* plantlet is much smaller than enset suckers (compare Waman *et al.*, 2015 with Figure 2), and such plantlets are thus more sensitive to drought or competition from weeds. In addition, enset is usually grown on small farms (Tsegaye and Struik, 2002; Tesfaye, 2008; Abebe *et al.*, 2010), by farmers who do not afford paying for planting material from expensive propagation techniques. However, in addition to suckers being large enough to plant directly in farmer's field, there are small suckers from each parent corm for potential further use (Karlsson *et al.*, 2015). Identifying the smallest sucker size meaningful to use and a systematic arrangement for treating these suckers to full development are important steps for an efficient resource utilisation in propagation.

There was no significant effect of mother corm pre-treatment (Table 1). Thus, for further size development, the important factor is the size of the planted sucker (Table 2), not how the sucker was produced. The sizes of individual pseudostems and corms were dependent on planting size during three years of undisturbed development (Figure 2). The correlation was less pronounced the last year (Table 2), which can be understood as the smallest plants being suppressed while those of intermediate size increased more than the largest during the later part of the growth period (Figure 2). In practice, relatively small suckers may better be planted separately in farmers' fields, as currently done in some areas (Pijls *et al.*, 1995).

There was significant effect of cultivar regarding corm and pseudostem volume at harvest (Tables 1 and 2); 'Endale' was smallest (Table 2, Figures 3A, B). However, 'Endale' produces more suckers per parent corm than other investigated cultivars (Karlsson *et al.*, 2015). Therefore, the number of possible mature plants may balance the smaller size.

There was no significant interaction with the factor cultivar at harvest (Table 1), showing that the genotypes, having their different inherent characteristics, responded with similar size development to a certain growth condition. Similar responses among landraces are also demonstrated with three landraces grown in pairs at three sites (Tsegaye and Struik, 2003). Therefore, management advice can be given for enset as a crop, without considering genotype, while the farmer's choice of genotype or genotypes to grow is important for characteristics as size, growth rate (Figure 3), and perceived food quality (Bosha *et al.*, 2016). Which cultivars or landraces farmers use depend not only on plant performance but on the intended purpose of the plant and personal preferences (Zippel, 2005; Yemataw *et al.*, 2016).

Because enset can survive relatively long periods of drought (Brandt *et al.*, 1997) and is suitable as fodder (Mohammed *et al.*, 2013), it is an important resource to many farmers with animals. If cutting off aboveground parts but leave the corm unaffected in the soil it gives a second harvest. These plants will use energy from the corm to re-sprout, thus depleting the underground stored energy, but as soon as there are green leaves again photosynthesis capture energy and additional feed for animals can be harvested later (Figure 3B).

When researching and developing enset agriculture, non-destructive sampling of easily recorded measurements can be used as estimation of enset plant weight. Base circumference and pseudostem volume were well correlated to weight (Table 2). It is preferable to not use any specific height of pseudostem to record circumference, because the pseudostem shape may be very different between plants individuals due to genotype, age or performance. To calculate pseudostem volume, we recorded (1) pseudostem height from soil surface to the point where the petiole of the lowest green leaf (at least 50% of blade area being green) begun to detach from the pseudostem, and (2) circumference at the middle of the recorded height of the pseudostem. Thereafter, the calculated radius to the recorded circumference and the recorded pseudostem height were used to calculate the volume, approximated to a cylinder. These measurements are applicable to all plants, and they are simple to record correctly. Even though pseudostem volume had slightly lower R^2 than base circumference in the correlation to weight (Table 2), we recommend using pseudostem volume because it is a robust general predictor of total plant weight; the record of base circumference may vary considerably if recording a few centimeters up or down the pseudostem (all our recordings were overseen by the same person).

It is important new knowledge that there is significant relation between sucker size at planting and plant size after further growth, even after three and four years of growth, and despite plants being cut off (Table 2, Figures 2 and 3). Thus, it is a clear message that effort to achieve large suckers from enset propagation is beneficial. Split parent corms give more suckers than if kept entire, while sucker size is not affected when the corm piece is at least 1 dm^3 (Karlsson *et al.*, 2015). However, it is possible that entire parent corms withstand prolonged drought after burial better than split corms. Circa seven to eleven L of pulverised dry cow manure is suitable to apply with each parent corm at burial (Bosha *et al.*, 2019). Moderate watering during a dry period after corm burial gives sooner emergence and suckers with more uniform size (Karlsson *et al.*, 2015).

In conclusion, we recommend developing the traditional vegetative way of enset propagation. Achieving larger suckers from improved management at corm burial is beneficial (Figure 2), and the smallholder farmer being the typical enset grower can handle and afford the entire procedure sustainably. Agricultural extension, for cattle and many crops, has a nearly 90 years' tradition in Ethiopia (Belay, 2003). In the same way, information about general practices, new knowledge, and improved technologies of enset agriculture can be spread to established and new enset farmers by educating the advisors and training farmers. Actions to enhance and advance enset agriculture among smallholder farmers would directly favour households with very limited resources and improve environments in the densely populated areas. It would also be beneficial to the global environment because these kinds of farms are among the superior carbon sinks in the tropics (Negash and Starr, 2015).

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