

Vegetative Propagation Techniques of *Oxytenanthera Abyssinica* in Benshangul Gumuz Region, Western Ethiopia

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Abstract

Bamboo is a fast-growing woody perennial and grass species that has a unique feature and quality. It has a high potential for socio-economic development and for environmental improvement. The present study was conducted in Benshangul Gumuz Regional state of Western Ethiopia, a highly bamboo dominated area. This study aims to identify the best vegetative propagation technique for *Oxytenanthera abyssinica* species. The propagation materials tested were off-set, rhizome without nodes, rhizome with two nodes and whole Culm. The survival rate, the number of newly sprouted shoots; their length and the root collar increment data were collected. There was a significant difference in the number of newly emerged shoots among the propagation methods applied. Higher numbers of sprouted shoots and survival rates were recorded in the treatments including off-sets and rhizomes with two nodes than the remaining treatments of rhizomes without nodes and whole Culm. Moreover, there was a significant difference of shoot length among the different propagules, while on the other hand; there was no significant difference in root collar diameter among the treatments. The findings suggest that two-node rhizome propagation technique is more appropriate for large and small-scale plantations of *Oxytenanthera abyssinica*.

Keywords: Bamboo, Culm, Off-set, Rhizome and Shoot .

Introduction

Bamboo is a fast-growing woody perennial belonging to the family of grasses, Gramineae (Poaceae), with unique features (Bareja, 2010). It is evergreen plant that produces primary shoots without later secondary growth. Each shoot has a distal aerial part, proximal ground level part, a subterranean part called culm, culm neck and rhizome respectively. Culms consist of nodes and internodes with meristematic (Kleinhennz and Midmore, 2005). Bamboo is also a versatile renewable resource with a high potential for socio-economic development and environmental improvement (Rao *et al.*, 1996; Kassahun, 2000).

Ethiopia has two indigenous bamboo species: the African Alpine Bamboo (*Yushane alpine* K. Schumann Lin; synonym: *Arundinaria alpine* K. Schumann) and the monotypic genus *Oxytenanthera abyssinica* (A. Richard) Munro. These species are also found in some other African countries, but nowhere else outside the African continent. Ethiopia contributes the largest coverage of bamboos in Africa, giving out more than 1 million hectares. This constitutes about 67% of the total area of bamboo on the continent (Kassahun, 2000; Yeshambel, *et al.*, 2011; Abiy, 2013).

Bamboo has diverse socio-economical (goods), environmental and ecological importance (services) at local, regional, national and global levels (Yohannes *et al.*, 2018). In Ethiopia, bamboo has significant role in providing employment and economic growth opportunities for rural and urban communities (Mulugeta, 2013). It also contributes more in generating income since it can be processed into products for domestic use and export market (Regassa, *et al.*, 2016).

Flowering of *Oxytenanthera abyssinica* seems to be more frequent and it flowers every 30-35 years. Currently, mass flowering there by mass death has reached over 85% of the estimated total 400,000 ha bamboo region, which might havoc the whole ecosystem and lives dependent on bamboos (Demissew *et al.*, 2011). Due to rapid increment of the country population growth the bamboo resource become declined at an

alarming rate that demanding the resource by the local people directly and indirectly like for food, house construction and shifting the bamboo land for agricultural crops.

Concerning the above problems, the Ethiopian government has established a new Environment and Forest commission, designing afforestation and reforestation program in order to increase the forest coverage of the country. The government promotes bamboo planting of in regions of the country where steeper and higher uplands are found (Yared *et al.*, 2017).

Bamboo naturally can be propagated either by sexual (reproductive) or asexual (vegetative) methods. Artificial propagation by vegetative methods includes planting of offsets, Culm cuttings, layering, and grafting of rhizome (Kssahunet *al.*, 2002). Sexual propagation is accomplished through seeds (Demelash *et al.*, 2012). However, this is not a usual propagation method in Ethiopia due to the irregularity and rarity of the flowering of common bamboo species. Currently, since planting bamboo on a larger scale has increased in Ethiopia, cost-effective and efficient propagation techniques are required. Though, the viability of seeds of *Oxytenanthera abyssinica* is relatively longer (three years,) and has a higher germination rate, seeds are not always available regularly (LUSO Consult, 1997; Azene Bekele, 2007; Demelash *et al.*, 2012). Besides, culms produced from seed need a longer period (seven years) to reach harvestable size. Under these circumstances, other effective propagation techniques must be chosen. Clonal /vegetative propagation is cost-effective and desirable for large-scale applications (Reddy, 2006). Moreover, different parts of bamboo plants are used as propagation material, offsets, Culm cuttings, layering, and grafting of rhizome (Dereso, 2019).

A clump-based vegetative propagation technique is a time-tested and widely practiced method in Asia (Banik, 1995). A segment is severed or separated from the parent rhizome and treated to develop into an independent source of planting material. The detached part of the rhizome carries all the elements needed for the growth of a new plant. It may be separated from other parts of the plant such as rhizome, offsets, roots and Culm. Common to all methods of rhizome-based propagation is the cutting away of a part of the rhizome from a healthy and mature clump.

Nevertheless, studies on vegetative propagation of *Oxytenanthera abyssinica* species in Ethiopia are limited. Therefore, this study aims to establish a protocol for an effective propagation method of this bamboo at normal nursery conditions.

Material and methods

Study area description

This study was conducted in the western part of Ethiopia, Assosa as indicated. Assosa is located 12°58'N 36°12'E with an altitudinal range of 600-1200 masl; annual rainfall ranges from 800 to 1390 mm with a mean annual rainfall of 965 mm, and its average monthly minimum and maximum temperature is 19.6 and 35.5 °C, respectively. The planting site was a well-drained soil on a gently sloping land. The availability of water sources was also taken into consideration, so that water supply was possible during the dry spells, up to six months of the experimental period.

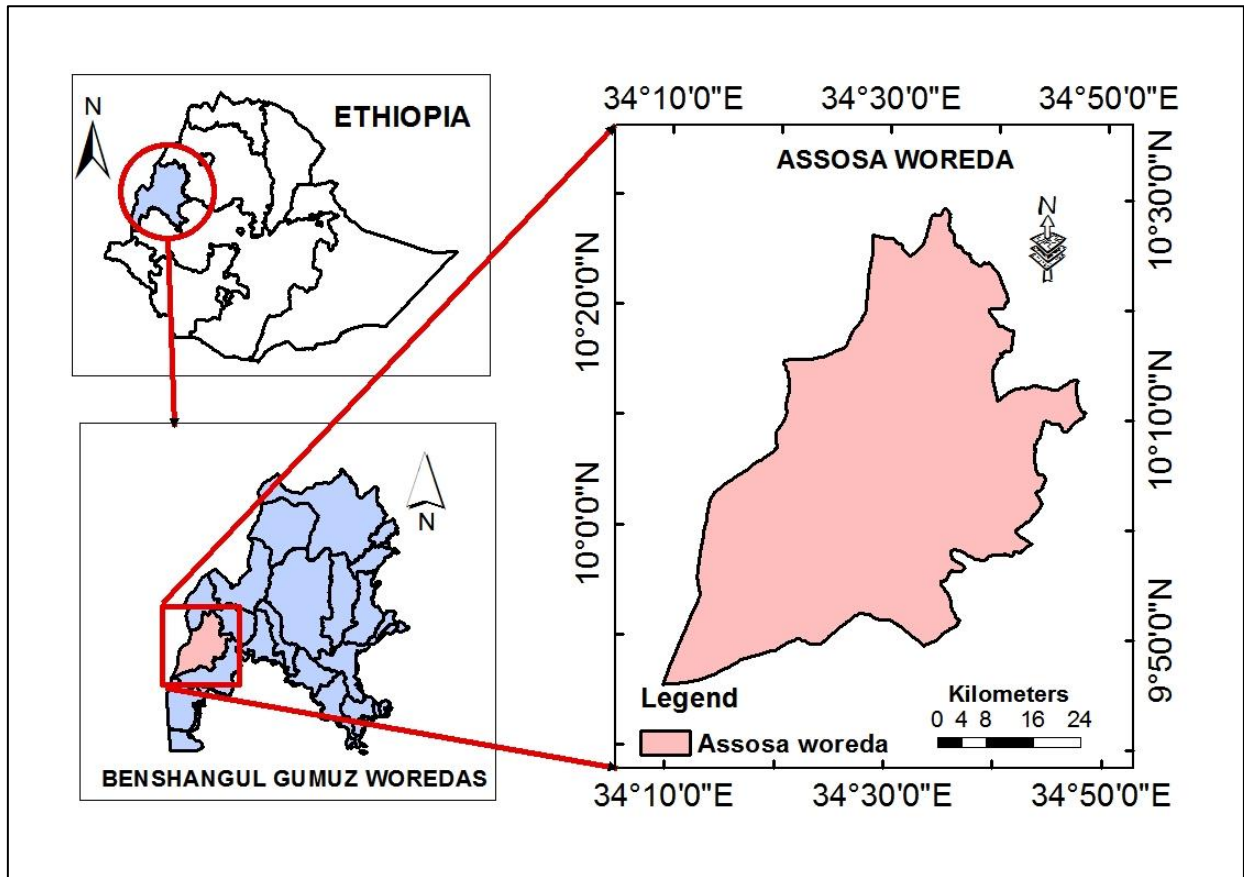


Figure 1: Area of study

Treatments and Experimental design

For this experiment, propagation manuals of tropical bamboos by Banik (1995);Ronald (2005) were followed. As propaguoles off-set, rhizome without nodes, rhizome with two nodes and whole Culm were used. Planting materials were collected from a bamboo forest nearby Assosa town. The treatments were laid in randomized complete block design with three replications and nine planting material planted for each plot and the spacing between plants was 4m.

The trial was established on August 1st 2014, when the soil was sufficiently wet, following the start of the main rainy season. Additional water was Supplying when the rain was absent more than a day from December to May. A layer of grass mulch was applied within each planting material in order to retain moisture, reduce evaporation and protect them from direct sunlight. Weeding and hoeing were done twice in each rainy season (June to October). The experiment was conducted from 2014 to 2016. The number of new shoots emerged, shoot length, root collar diameter and survival rate were recorded every six months (totally three times). Normality and homogeneity of variances were checked before the actual analysis. Data analysis was made using SPSS 20. One-way ANOVA was conducted and the Least Significance Difference (LSD) test was used.

Results and Discussions

Effect of different propaguoles and time on the vegetative propagation of *Oxytenanthera abyssinica* Shoot Sprouts

The average numbers of sprouted shoots of the treatments are presented in table (1). The results showed that the number of new shoots produced was significantly different among propagation methods ($P=0.02$). The mean number of new shoots was higher in offsets and rhizomes with two nodes (14 ± 3.28 and 11 ± 1.49 , respectively) than rhizomes without nodes and whole Culm (6.44 ± 1.35 and 4.11 ± 2.25 , respectively) (Table 1). Time trends indicated that there was a statistically significant difference in the mean number of newly sprouted shoots as time progressed ($P=0.032$) (Annex). In all propaguoles, new shoots emerged within six months after establishment of the experiment. Kassahun, (2000) stated that new bamboo shoots are produced after three years of establishment by seed. During our data collection time, more new sprouted shoots were emerged in the rainy season (Figure 2), whereas water fluctuation and termites was a strained for emerged sprouted shoots. Similar studies, (Batabyal and Tah, 2013;Yared *et al.*,2017) reported that the sprouting rate of shoots after planting varied with different propaguoles depicting a high number of high land bamboo shoots during the wet season. According to Yigardu and Masresha (2014) new shoots of high land bamboo were challenged by strong winds, season and water fluctuation.



Figure 2: Sprouted shoots of *Oxytenanthera abyssinica* at summer season

Survival rate

The mean survival rates in different propagation techniques of *Oxytenanthera abyssinica* were significantly different ($P=0.00$). Relatively higher, mean survival rates were recorded in offset and rhizome with two-node (60.44 ± 2.93 and 59.32 ± 3.25) than rhizome without nodes and whole culm (17.42 ± 1.64 and

22.2±7.99) propagation techniques as indicated in table (1). The result indicated that the mean survival rate of offset had lesser differences with rhizome with two-node propagation techniques. However, Offset propagation techniques had a great difference with rhizome without node and whole Culm propagation techniques of *Oxytenanthera abyssinica*. The survival rate of different propagation techniques of *Oxytenanthera abyssinica* along consecutive ages did not significantly different ($P=0.967$) (Annex). However, there are fewer variations of survival rates of different propagation techniques along growing ages as indicated in figure (3b). The time trend indicated that the mean survival rate of the whole Culm propagation technique was higher in the first six months but it was becoming to decrease when the growing ages increase as indicated in figure (3b). This propagation system might be indicated a false survival rate without developing roots to uptake the nutrient and water because after planting it emerged new leaf and then most of the shoot emerged plants were dried.

Root collar diameter

The average root collar diameter of different propagation techniques as described in the table below. There was no significant difference in the mean diameter increment between propagation techniques as indicated in table (1). Even though there is no statistically significant difference was observed under mean diameter increment, the higher shoot diameter increment was recorded in offset and rhizome without nodes (15.05±3.90 and 13.53±3.57) than rhizome with two nodes and whole Culm (12.54±3.06 and 5.47± 3.44) propagation techniques. As the result showed that a whole Culm propagation technique had the lowest shoot root collar diameter increments, this might be due to a lack of food storage rhizome part. The remaining three propagation techniques (off-set, rhizome without node and rhizome with two nodes) have attached with rhizome, which is helping to emerge thick shoots. A similar study in the highland bamboo (Yigardu and Masresha, 2014; Yaredet al., 2017), reported that the lowest diameter increment was recorded at whole Culm propagation techniques. There was a highly significant difference in the mean root collar diameter between all propagation techniques through time trends ($P=0.00$)(Annex). Sprouted shoots of root collar diameter of all propagation techniques were become increased along with time trends or ages as shown in figure (3c).

Length of sprouted shoots

There was a significant difference in the mean height growth of sprouted shoots between propagation techniques ($P=0.03$) as indicated in table (1). The highest average height growth of sprouted shoots was recorded in offset propagation techniques (193±41.32) which compared with rhizome without node, rhizome with two nodes and whole Culm propagation techniques (156.65±40.32; 163.80±29.86 and 50.91±25.03) as indicated in table (1). Relatively in whole Culm propagation techniques, least sprouted shoot height increments were recorded. There was a highly significant difference in the mean height growth of sprouted shoot between all propagation techniques through time trends ($P=0.00$)(Annex). The time trend indicated that the height means sprouted shoot of propagation techniques became increase and the highest mean shoot growth recorded at the end of the data collection period. Whereas the least mean shoot height growth was recorded at the initial period as indicated in figure (3).

Table 1:- Effect of different propaguoles on the vegetative propagation of *Oxytenanthera abyssinica*.

Treatment	Off-set	Rhizome without node	Rhizome with two nodes	Whole Culm	P-value
	Mean ± Std.SE	Mean ± Std.SE	Mean ± Std.SE	Mean ± Std.SE	
Number of new shoots	14±3.28	6.44±1.35	11±1.49	4.11±2.25	0.02
Survival rate (%)	60.44±2.93	17.42±1.64	59.32±3.25	22.20±7.99	0.00
Root collar diameter (mm)	15.05±3.9	13.53±3.57	12.54±3.06	5.47±3.44	0.24
Shoot length (cm)	193.7±41.32	156.65±40.32	163.80±29.86	50.91±25.03	0.03

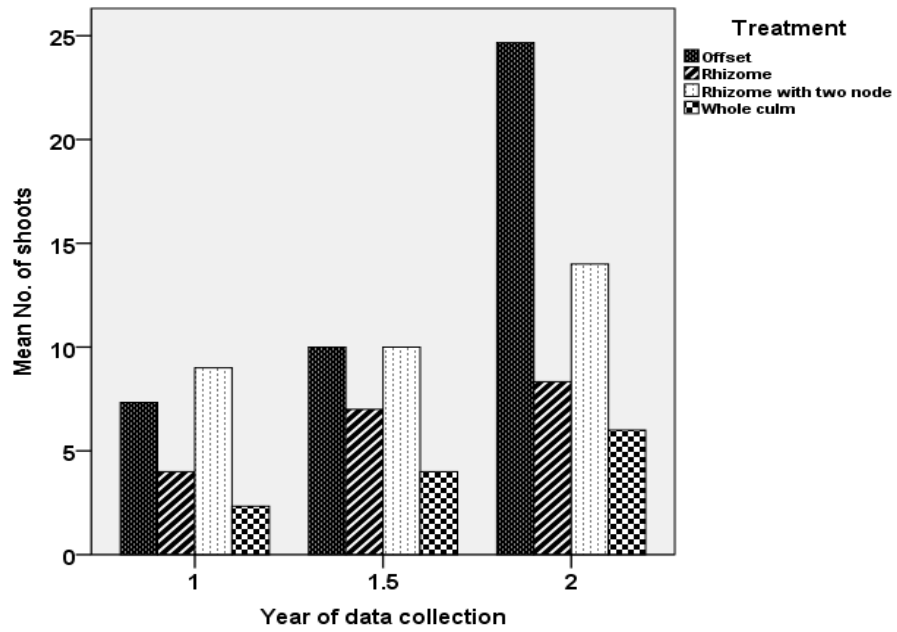


Figure a

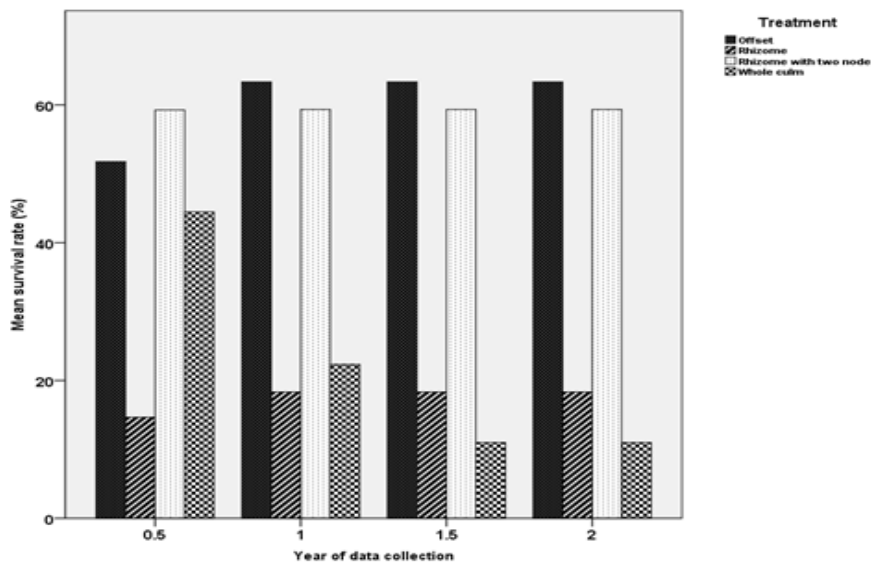


Figure b

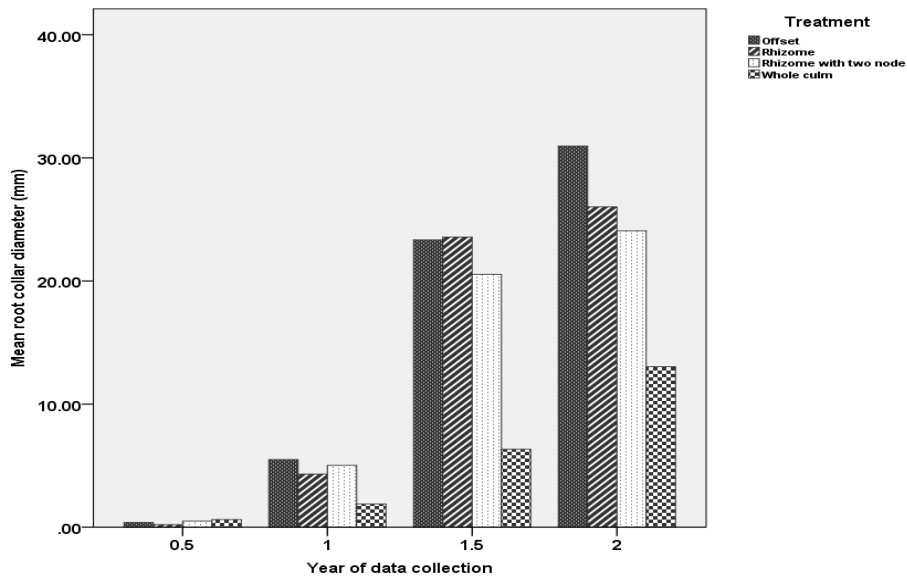


Figure c

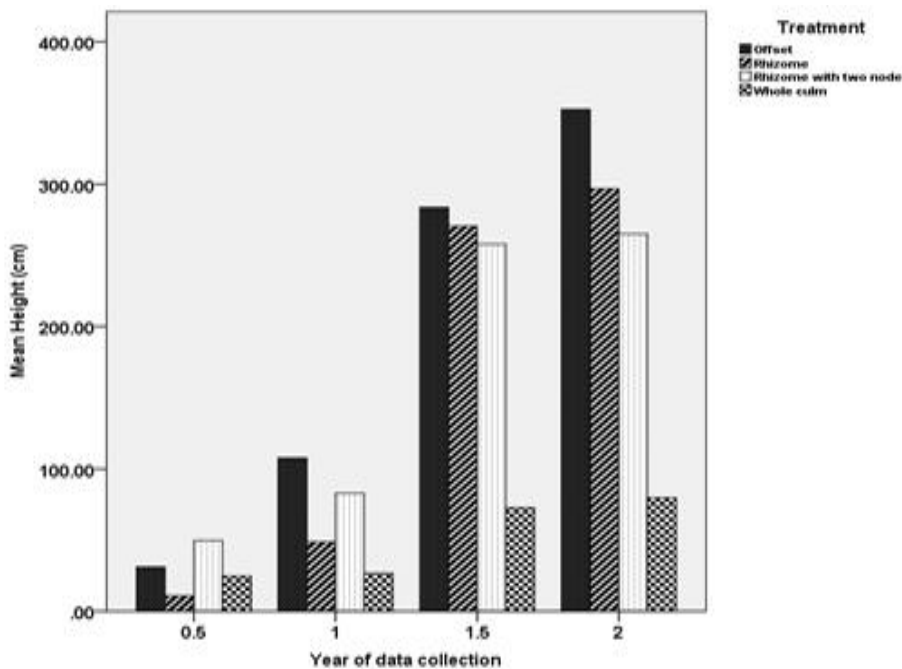


Figure 3: Effect of propaguoles type and time after planting on vegetative propagation of *Oxytenanthera abyssinica*

Pearson correlation coefficients

The correlation between a number of shoot sprout and age was described in table (3). The correlation between the number of shoot sprout and age ($r=0.419^{**}$) was weak and positively correlated. It was significant at 0.05 and 0.01 level ($P=0.005$) in table (3).

Table 3: Pearson correlation coefficients between numbers of shoot sprouts and ages

Variables	No.of shoots	Time (year)
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No.of shoots	Pearson correlation Sig. (1-tailed)	1	0.419** (P=0.005)
Time	Pearson correlation Sig. (1-tailed)	0.419** (P=0.005)	1

Conclusions and Recommendations

The number and length of the emerged bamboo shoots were higher in rhizome-based propagation techniques than whole-Culm propaguoles. The poor performance of small-sized planting materials appears to be related to the lower amount of food reserve.

Propagation through off-set in the local community is traditionally known as old age methods Of *Oxytenanthera abyssinica* propagation. However, it is mainly inappropriate for large-scale plantation, due to labor intensiveness, time consumption, transportation, and other logistical costs. According to the present findings, off-sets and rhizomes with two nodes had not shown big differences in the number of sprouted shoots and performances along with time trends.

According to the findings of this study, rhizomes with two nodes have proved to be the best propaguoles of *Oxytenanthera abyssinica* for large-scale propagation as well as for a small-scale plantation. During the experiment, the planting materials were significantly strained by termite infestation and water stress. Therefore, further research on disinfection treatments and other management practices are recommended to increase the persistence of new bamboo shoots.

Disclosure Statement

The authors reported no potential conflict of interest.

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Appendix

Annex : ANOVA result along with time sequences

Parameters		Sum of Squares	df	Mean Square	F	Sig.
No. of shoots	Between Groups	368.389	2	184.194	3.811	0.032
	Within Groups	1595.167	33	48.338		
	Total	1963.556	35			
Survival rate (%)	Between Groups	180.682	3	60.227	.087	0.967
	Within Groups	30526.316	44	693.780		
	Total	30706.998	47			
Root collar diameter (mm)	Between Groups	4426.883	3	1475.628	23.966	0.000
	Within Groups	2709.205	44	61.573		
	Total	7136.087	47			
Height (cm)	Between Groups	432928.844	3	144309.615	18.284	0.000
	Within Groups	347268.754	44	7892.472		
	Total	780197.598	47			