FORCE REQUIREMENTS OF DIFFERENT MANUAL PRUNING SHEARS WHEN CUTTING ABELIA *(ABELIA GRANDIFLORA)* BRANCHES

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Abstract
The article is focused on comparative investigation of some pruning shears(bypass) in terms of cutting forces and design when cutting Abelia branches. Three different by-pastype pruning shears were selected to evaluate. Abelia branches were used as a material in the tests. The experiments were carried out at a constant speed of 300 mm/min and 6 replicates in two different diameter groups (4.89 mm and 6.93 mm). The shear force data was obtained using a Lloyd tester and a computer with NEXYGEN software. The diameters of braches were included in the model as covariates and their effect was eliminated from the model and only the effect of the design characteristics of the shears on the force values was investigated. The LSD test was used for comparisons between means and covariance analysis was used for data analysis. The results were statistically significant at 1% significance level. According to the results; the smallest force values were obtained by first shear for both diameter groups (32.54 N-85.11 N). All the data were taken into consideration; it was seen that the first shears performed the same process with less force than the other shears in terms of cutting forces.

Key words: *pruning shear; shear force; abelia branch; ergonomic design.*

INTRODUCTION

The genus Abelia contains 30 species that vary in many traits including cold hardiness, flower color, and growth habit. Abelia ×grandiflora (André) Rehd. is widely used in the landscape because of its prolific floral displays of pinkish-white flowers and glossy semi-evergreen to evergreen foliage *(Scheiber, Robacker & Lindstrom, 2002)*. (Fig. 1).

Fig. 1 Abelia (Abelia grandiflora)

Pruning process is an important part of cutting flower cultivation. Production costs and power requirement are very high and labor efficiency is lower than the other operations (*Pekitkan, Eliçin & Sessiz, 2019*). Pruning is regular and productive technique practiced in ornamental plants for controlling the growth, enhancing the yield and shaping the plant *(Akhtar, Akram, Sajjad & Farooq, 2016)*. Furthermore, from an ergonomic point of view, it is possible to say that pruning is also in the category of repetitive work. In general, most manual pruning shears fall into two basic types: anvil and bypass. (Fig.

2). Finally, some pruning shears require a bigger hand force to cut a given thickness of branch than do other models.

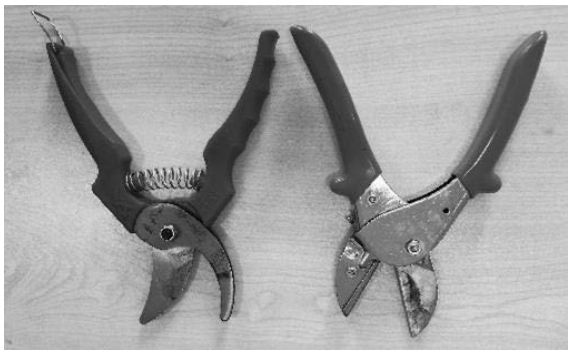


Fig. 2 Bypass and Anvil type pruning shears

Fig. 3 Lloyd instrument universal testing machine

Regarding manual repetitive works, some limit values for human health have been reported, such as pruning in agricultural production and maintenance. According to the EN-1005-3 standard, it is desirable that the force to be applied by the hand is not above 300 N and desirable values should be in the rage of 150-200 N, if possible. There are many references to pruning and pruning shears in the literature, but they do not address hand force for repetitive actions or design effect on efficiency. They are generally dealing with information on plant properties and the power or energy requirements of an equipment (*Persson, 1987; Emadi, Kosse & Yarlagadda, 2004; Voicu, Moiceanu, Sandu & Poenaru, 2011; Esehaghbeygi, Hoseinzadeh, Khazaei & Masoumi, 2009; Hoseinzadeh &Shirneshan, 2012; Selvi & Kabaş, 2016*). No references to tests of pruning shear hand force requirements were found enough about ornamentals. The objective of this study was to compare low cost bypass hand pruning shears and which ones required the low hand force especially in terms of their design and also for hand health according repetitive works.

MATERIALS AND METHODS

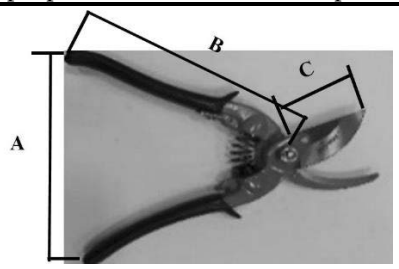
Plant material

In the shear tests, abelia branches were obtained from a commercial garden in Samsun province located in North of the Turkey. The test samples were randomly cut by hand from garden. The collected branches were transported to the laboratory at the Department of Agricultural Machinery and Technologies Engineering, University of Ondokuz Mayıs which were then placed in a refrigerator at 5 °C until the time of the cutting tests. The test procedure consisted of measuring the force on the handle required to cut abelia branches in two different diameters: 4.89 mm and 6.93 mm.

Pruning shears

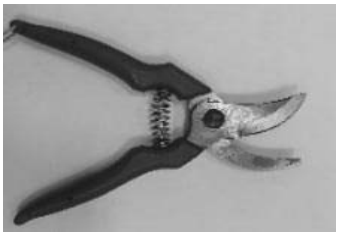
Three low cost hand pruning shears were selected for evaluation in this study. The models are listed in Table 1, together with some properties.

Tab.1 Some properties of low cost hand pruning shears



Dimensions mm		
	A	150
	B	156
	C	67

Model name	Type	Blade thickness mm	Blade angle °	Weight g	Cost Euro
Bulmax BMX-286	By-pass	2.2	8.25	471	5.21

			Dimensions mm	**A**	123
				B	136
				C	52
Model name	Type	Blade thickness mm	Blade angle °	Weight g	Cost Euro
Akman	By-pass	3.7	21.05	187	4.78

			Dimensions mm	**A**	150
				B	150
				C	60
Model name	Type	Blade thickness mm	Blade angle °	Weight g	Cost Euro
Yeniay	By-pass	4.4	13.71	365	3.79

All of the pruning shears were purchased new for this evaluate. The plant materials were pre-experimented to simulate manual cutting, with a repetition of 300 mm/min at constant speed and 2 different diameter groups (4.89 mm and 6.93) with 10 replications.

Testing device and apparatus

The force required to cut hazelnut suckers with different pruning shears was measured by a Lloyd Instrument Universal Testing Machines (Lloyd Instrument LRX Plus, Lloyd Instruments Ltd, An AMATEK Company). The device has three main parts: moving head, driving unit and data acquisition system (load cell, note book and connections and NEXYGEN Plus software). The device was equipment with a load cell of 1000 N and measurement accuracy of load cell was 0.5%.

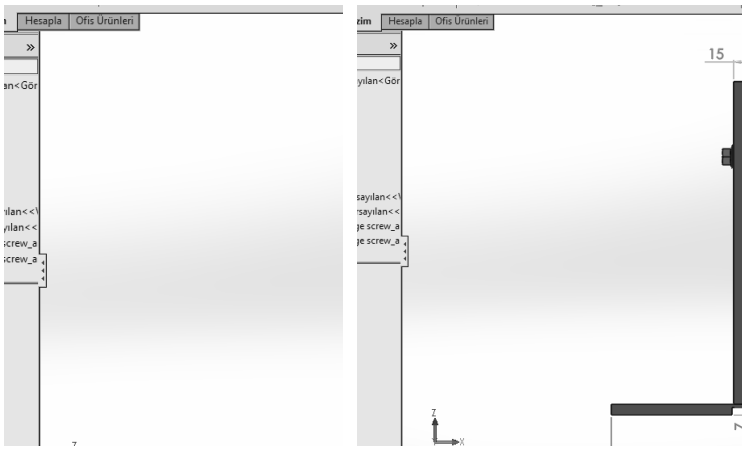


Fig. 4 Clamping apparatus to the Lloyd LRX Plus tester

Load cell was fixed to moving head (Fig.3). In the experiments, a clamping apparatus has been manufactured in order to enable the cutting shears to perform the correct cutting operation and to be mounted on the test device. The detail picture and dimensions of the clamping apparatus is shown in Fig. 4.

RESULTS AND DISCUSSION

The mean forces of the pruning shear to cut abelia branches are shown in Fig.5 and Fig.6. All three hand shears were able to cut all branches belonging to two different diameter groups in the experiment. Significant differences in cutting force requirements were noted. In the first diameter group; the highest shear force value was found to be 163.86 N for second diameter and at second shear, whereas the smallest shear force value was 32.54 N for first diameter group and at first pruning shear.

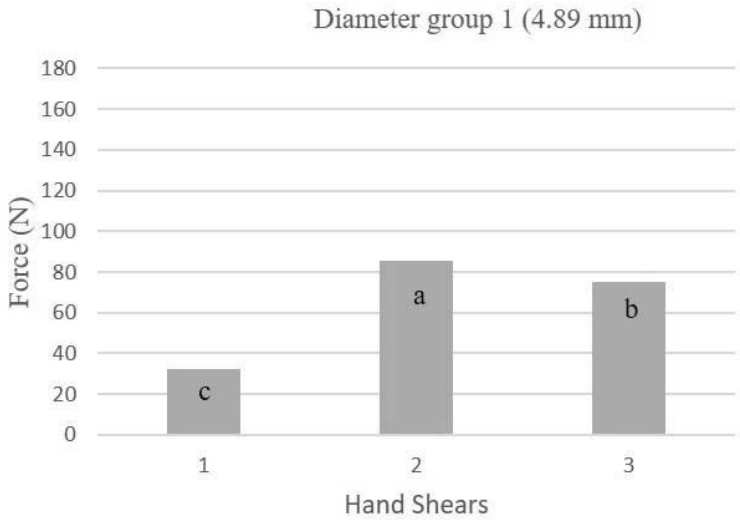


Fig. 5 Measured forces for diameter group 1.

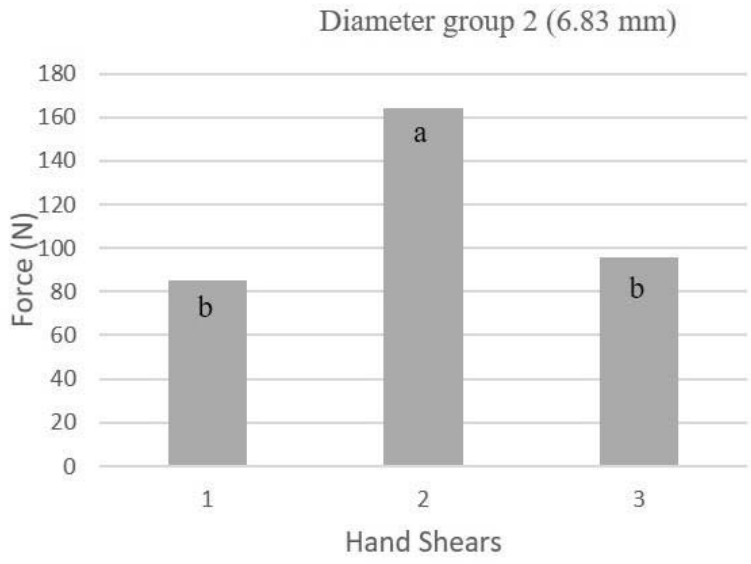


Fig. 6 Measured forces for diameter group 2.

Average shearing force values obtained with different pruning shears were 32.54, 85.68, 75.20 N for first diameter group respectively. The same values were 85.11, 163.86, 95.57 N for second diameter group. It can be seen that from the Fig.5, for the first diameter group, first pruning shear was able to perform approximately 2.5 times less force compared to the other shears. One reason maybe that the

thickness of the first pruning shears is less than the other shears. Thus the blades enter the material with less force and less impact on the lateral frictional resistance.
In addition, blade angle values support this result. In the study of *Mathanker, Grift & Hansen*, 2015, It supports the fact that the regulation of blade angles effects the cutting energy values and is therefore directly related to the force values. On the toher hand the maximum grip strength of a healthy young male using pliers like hand tool is approximately 600 N. For repeated and continuous work 33-50% of the above values is recommended *(Paivinen, 2002)*. From this point of view, three shears tested in this study were able to perform cutting operations below these values. The study results showed that, all pruning shears values tested with abelia branches in this study ergonomically below the limit values.

CONCLUSIONS

All pruning shears in this study required low operating force under ergonomic limits and were inexpensive. The average shear force varied between 35.54 N – 163.86 N. Also, results showed that the average cutting force of first pruning shear (Bulmax BMX-286) was significantly lower than rest of the other both pruning shears.

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