Effect of Various Knife Type, Cutting Angle and Speed on Cutting Force and Energy of Grape Cane

Ahmet Konuralp Eliçin1*, Abdullah Sessiz2, Fatih Göksel Pekitkan3

1 Dicle University, Faculty of Agriculture, Dept. of Agricultural Machinery and Technologies Engineering, Diyarbakır, Turkey (ORCID: 0000-0003-3240-4547)
2 Dicle University, Faculty of Agriculture, Dept. of Agricultural Machinery and Technologies Engineering, Diyarbakır, Turkey (ORCID: 0000-0002-3883-6793)
3 Dicle University, Faculty of Agriculture, Dept. of Agricultural Machinery and Technologies Engineering, Diyarbakır, Turkey (ORCID: 0000-0002-7791-7963)

(İlk Geliş Tarihi 26 Şubat 2019 ve Kabul Tarihi 25 Mart 2019)

(DOI: 10.31590/ejosat.532914)

REFERENCE: Eliçin, A.K., Sessiz, A. & Pekitkan, F.G. (2019). Effect of Various Knife Type, Cutting Angle and Speed on Cutting Force and Energy of Grape Cane. Avrupa Bilim ve Teknoloji Dergisi, (15), 519-525.

Abstract
In this study, some cutting and energy properties of canes of local grapes varieties Okuzgozu (Vitis vinifera L. cv.) were determined depend on knife type, cutting angle and cutting speed during the spring pruning in 2018. The canes of grapes were obtained from a commercial farm in the Diyarbakır province. Cutting properties were measured by a material testing machine. According to test results, the significant differences were found between the knives types at 1% probability level. The best results were determined at the flat knife knife type, followed by serrated 2 and serrated 1, respectively. While the lowest cutting force and cutting strength values were obtained at flat type (knife edge flat) as 234.50 N, 8.299 MPa, 1.783 J and 0.06307 J mm$^{-2}$ respectively, the highest values cutting forces, cutting strength, cutting energy and specific cutting energy were obtained at serrated type 1 (knife edge thin) knife as 303.8 N, 10.75 MPa, 2.136 J and 0.075610 J mm$^{-2}$ respectively. The cutting force and energy values decreased with increasing knife-cutting angle from 0° to 40°. The maximum cutting force, cutting strength, cutting energy and specific cutting energy were observed at 0° cutting angle as 319.3 N, 11.30 MPa, 2.393 N and 0.08464 J mm$^{-2}$ respectively. The effect of the knife loading speed on the cutting forces, cutting strength, cutting energy and specific cutting energy were found significant statistically (p<0.01). The lowest cutting force, cutting strength, cutting energy and specific cutting energy were obtained at the 1 m s$^{-1}$ as 246.1 N, 8.705 MPa, 1.273 J and 0.04502 J mm$^{-1}$, respectively.

Keywords: Grape cane, Cutting force, Cutting energy, Pruning.

* Corresponding author: Dicle University, Faculty of Agriculture, Department of Agricultural Machinery and Technologies Engineering, Diyarbakır, Turkey, ORCID: 0000-0003-3240-4547, akelicin@gmail.com

http://dergipark.gov.tr/ejosat
1. Introduction

Pruning and harvesting operations are the most critical stages in the management of the vineyards. Even though grape has always been a valuable and important product for human diet and economy in Turkey, pruning and harvesting processes in vineyards are still mainly performed by worker with scissors in viticulture. Also, the same scissors are used for all types of vine. We know that the cane cutting characteristics of each variety is different each other. Therefore, the mouth of the used scissors and the cutting angle are important to determine for reducing the energy requirement. Usually, flat-mouthed scissors are used and this method of conventional pruning process is difficult and tiring. Therefore, production costs and crop losses are very high, power requirements are high and labor efficiency is low. Moreover, Labor requirement, time-consumption and production costs can be decreased by utilizing a mechanical pruner and grape harvester (Morris, 2000; Sessiz et al. 2015).

For the design and manufacture of a new pruning shears and machines, it is necessary to know the require force and energy values of grape canes. The cutting properties and energy requirement depend on the species, variety, diameter, maturity, moisture content, cellular structure and the type of cutting blade used (Persson, 1987; Ammer Eissa et al. 2008; Taghijarah et al. 2011; Nowakowski, 2016). Knife edge angle, knife approach angle, shear angle, and knife rake angle are the most important knife angles that can directly influence the cutting force and energy (Ghahraei et al., 2011).

Until now, many studies have been conducted on the mechanical and physical properties of agricultural products and biological materials such as fruits, grains and seeds. However, it was observed that the results of published studies were not related directly with the cutting properties of grape internodes of canes and their relations (Ozdemir et al., 2017a; Esgici et al., 2017). Romano et al. (2010) determined the cutting force for certain vine branches such as Cabernet Sauvignon and Chardonnay at different regions in Italy. Sessiz et al. (2015) determined the cutting properties for some grape varieties in Turkey. Some physical properties of the Rasa grape were determined by Khodaei and Akhijahani (2012). Cutting properties of some wine grape cultivars were determined by Ozdemir et al. (2015). Similar results were reported by Yore et al. (2002) for rice straw, by Kronsberg et al. (2011) for hemp stalk, by Alizadeh et al. (2011) for rice stem, by Ghahraei et al. (2011) for kenaf stems, by Sessiz et al. (2013) for olive sucker, by Ozdemir et al. (2015) for grape sucker, by Sessiz et al. (2015) for cane of some different grape variety, by Pekitkan et al. (2018) for cotton stalk.

The objectives of this study were to determine the effect of the knife type, knife edge angles and cutting speed on cane cutting force, cutting strength and energy requirement for local Okuzgozu grape variety.

2. Materials and Methods

This study was carried out using Okuzgozu local grape variety canes (Figure 1). The test materilas were obtained from a commercial vineyard at the Diyarbakir province located in south-eastern part of Turkey. The cut and collected grapevine canes from vineyard (Figure 1) were transported to the laboratory at the Department of Agricultural Machinery and Technologies Engineering, University of Dicle which were preserved in a refrigerator at 5°C until the time of the cutting tests. The experiment tests were performed during grape pruning season in 2018 year.

Figure 1. Okuzgozu local grapes variety canes.

The canes with an average diameter of 6 mm were used as test material. The ranges of internode diameter of the canes (mm) were converted to cross-section area in 28.26 mm² for Okuzgozu grape variety. The cane diameters were measured before the test using a caliper. The initial moisture content of canes was determined according to ASABE standard (ASABE Standards, 2008) by way of oven-drying 50 g of each sample at 105°C for 24 h. The moisture content was determined as 37.80 % w.b.

An Universal Testing Machine was used to measure cutting force and energy requiremnt of canes (Figure 2). The cane samples were placed on the machine loading table in a flat position during the tests. Loading was applied vertical direction. Cutting experiments were carried out with three various knife types (Figure 2), two of them are serrated type (Serrated 1 (knife-edge thick), Serrated 2 (knife-edge thin) and Flat (knife-edge flat) with five knife edge angles (0°, 10°, 20°, 30° and 40°) and five different loading speeds (1, 2, 3, 4 and 5 mm s⁻¹).
The maximum cutting force, cutting strength, cutting energy and specific cutting energy were determined depend on type of knife, knife cutting angle and loading speed. The peak cutting strength, obtained from the cutting force findings, was determined by the following equation (Mohsenin, 1986; Sessiz et al., 2013):

$$\sigma_s = \frac{F_{\text{max}}}{A}$$

(1)

Where: $\sigma_s$ is the maximum cutting strength in (MPa), $F_{\text{max}}$ is the maximum cutting force in (N) and $A$ is the cross-sectional area in ($\text{mm}^2$).

The cutting energy was calculated by measuring the surface area under the force-deformation curve via material testing machine (Georget et al., 2001; Yore et al., 2002; Chen et al., 2004; Kocabiyik and Kayisoglu, 2004; Amer Eissa et al., 2008; Ekinci et al., 2010; Zareiforoush et al., 2010; Ghahraei et al., 2011; Heidari and Chegini, 2011; Voicu et al., 2011; Sessiz et al., 2013; Sessiz et al., 2015; Nowakowski, 2016; Ozdemir et al., 2017b; Pekitkan et al., 2018). A computer data acquisition system recorded all force-displacement curves during the cutting process.

Specific cutting energy, $E_{\text{sc}}$ was calculated by:

$$E_{\text{sc}} = \frac{E_c}{A}$$

(2)

Where: $E_{\text{sc}}$ is the specific cutting energy (J mm$^2$) and $E_c$ is the cutting energy (J).

The experiment was planned as a completed randomized plot design and data were determined using analysis of variance (ANOVA) method. Mean separations were made for significant effects with LSD and the means were compared at the 1% and 5% levels of significance using the Duncan multiple range tests in MSTAT-C software.

3. Results and Discussion

The results of the cutting test showed that the significant differences were found between the serrated knife types and flate type at 1 % probability level (Table 1). However, there were not found significant differences between the serrated type 1 and serrated type 2 knives. As can be seen from the Table 1, the best results were determined at the flat knife knife type, followed by serrated 2 and serrated 1, respectively. While the lowest cutting force and cutting strength values were obtained at flat type (knife edge flat) as 234.50 N, 8.299 MPa, 1.783 J and 0.06307 J mm$^2$ respectively, the highest values cutting forces, cutting strength, cutting energy and specific cutting energy were obtained at serrated type 1 (knife edge thin) knife as 303.8 N, 10.75 MPa, 2.136 J and 0.075610 J mm$^2$ respectively.

According these results, the flat type knife is suitable than the serrated type knives for cutting and pruning of Okuzgozu grape cane. When we compared the knife types and we can recommend that the flat type than serrated type knife for a new design of cutting machine and pruning for the cane of Okuzgozu grape variety.

The effect of knife cutting angle on cutting force, cutting strength, cutting energy and specific cutting energy are shown in Table 1. As shown in the table, the cutting angle has been significant effect on the cutting force, cutting strength, cutting energy and specific cutting energy of grapevine canes (P <0.01). The cutting force, cutting strength, cutting energy and specific cutting energy decreased with increasing knife-cutting angle from 0° to 40°. Also, according to results of variance analysis, the effect of interactions of factors were found significant (p<0.01) on cutting force, cutting strength, cutting energy and specific cutting energy. The most significant effect was found between 0° and 10° cutting angle to other cutting angle (20°, 30° and 40°). However, there was no significant difference among means for 20°, 30° and 40° at the probability level of 1 % and 5 %. The maximum cutting force, cutting strength, cutting energy and specific cutting energy were observed at 0° cutting angle as 319.3 N, 11.30 MPa, 2.393 N and 0.08464 J mm$^2$ respectively. The lowest values were obtained at 20°, 30° and 40° cutting angle. There were not found significant different statistically among these
The cutting force, cutting strength, cutting energy, and specific cutting energy were found significant statistically (p<0.01). The cutting force and cutting energy increased with increasing blade velocity. The lowest cutting force and cutting energy were achieved at the 1 m s⁻¹ as 246.1 N, 8.705 MPa, 1.273 J and 0.04502 J mm⁻², respectively. The cutting force and cutting energy were found significant statistically (p<0.01). The cutting force, cutting energy, and specific cutting energy increased with increasing blade velocity from 1 mm s⁻¹ to 5 mm s⁻¹. The lowest cutting force, cutting strength, cutting energy, and specific cutting energy were obtained at the 1 m s⁻¹ as 246.1 N, 8.705 MPa, 1.273 J and 0.04502 J mm⁻², respectively. However, there were not found significant differences among the 2, 3, 4, and 5 mm s⁻¹. Similar results were obtained by Chandio et al. (2013) for rice stem. According to this study, cutting force increased with increasing the load speed, and the shear energy did not change with knife loading speed. Khazaei et al. (2002) reported that by increasing the cutting speed from 20 to 500 mm min⁻¹, the shear energy decreased for flower stems. Zareiforoush et al. (2010) have been examined the effect of loading rate on mechanical properties of rice (Oryza sativa L.) straw. They reported that the effect of loading was not significant effect on cutting strength and cutting energy of rice straw. Similar results were obtained by Kusińska and Stardek (2012). They have been used variable parameters such as knife sharpening angle (2.5°; 7.5°; 12.5° and 17.5°) and velocity of its movement (0.83 mm s⁻¹, 1.66 mm s⁻¹, 2.49 mm s⁻¹, 4.15 and 10 mm s⁻¹) in experiments. Their test results proved significant dependence of the maximum cutting force value on changes of mechanical properties of tissues in relation to the place of collecting samples, the knife sharpening angle and its movement. The highest value of force was obtained during cutting with a knife of the sharpening angle of 17.5° and the lowest during the use of a knife with 2.5°. Along with the increase of the knife movement velocity, the cutting force decreased. The best quality of samples was obtained with the use of the velocity which was 2.49 mm s⁻¹ and 4.15 mm s⁻¹ with knives with the cutting angle of 2.5° and 7.5°. According to Iqathinathane et al. (2010), searing energy is depending on used knives, shear bars, and linear knife grids with ram. Dange et al. (2011) have determined cutting energy and force for Pigeon pea stems. They consider blade type, sharpened at 30° and 45° bevel angle were selected for the experiment. Mathaneker et al. (2015) conducted a study that the effect of blade oblique angle and cutting speed on cutting energy for energycane stems. The results showed that the specific cutting energy increases with cutting speed. The lowest average specific energy was 0.26 J mm⁻¹ for a 60° oblique cut at an average cutting speed of 7.9 m s⁻¹, whereas the highest average specific cutting energy was 1.24 J mm⁻¹ for a straight cut at an average cutting speed of 16.4 m s⁻¹. The effect of cutting velocity, diameter of stalks and types of blades on cutting energy, cutting force and specific energy for chickpea stalks were studied by Sushilendra et al. (2016). Jasim et al. (2017) have been investigated that the effect of knives type on some operational characteristics for a locally assembly motorized vibration cutter used for date palm fronds pruning. Singh et al. (2016a) conducted a study on the effect of varying knife speed and contact area on peak cutting force during slicing of peeled potato (Solanum tuberosum). In terms of product type and physical and mechanical properties of stem in crops, the estimation of harvesting efficiency in agricultural products can be completely different (Yiljep and Mohammed, 2005). Gan et al. (2018) reported that the designs of cutting blade is effect on energy consumption during moving-conditioning of Miscanthus Giganteus. Azadbakht et al. (2015) were conducted a study energy consumption during impact cutting of canola stalk as a function of moisture content and cutting height. The tests results showed the effect of height and moisture content on cutting energy is significant (P<1%). The minimum cutting energy was observed 0.76 kJ in 11.6 (w.b.) moisture content, 30 cm cutting height and 2.64 m/s blade cutting velocity. According to Singh et al. (2016b), the effective edge angle is 15° for cutting vegetables. Similar were conducted by Allameh and Alizadeh (2016) on the specific cutting energy for rice stem. The results revealed that rice cultivar and blade velocity had significant effects (P<0.01) on the specific cutting energy. When blade velocity increased from 1.5 m s⁻¹ to 2.5 m s⁻¹, specific cutting energy raised about 77 %. Blade cutting and bevel angles were not solely influential on the specific cutting energy but they interacted with rice cultivar and impacted it. Nandede et al. (2017) an investigation was conducted to study the effect of blade type, moisture content (MC) and diameter of the sorghum stalk and earhead on cutting energy as required for design of critical cutting component of sorghum harvester.

Table 1. The change of cutting and energy properties depend on knife type, cutting angle and cutting speed.

| Knife type                      | Cutting Force (N) | Cutting Strength (MPa) | Cutting Energy (J) | Specific Cutting Energy (J mm⁻²) |
|---------------------------------|-------------------|------------------------|--------------------|---------------------------------|
| Serrated type 1 (knife-edge thick) | 303.8 a*          | 10.75 a                | 2.136 a            | 0.07561 a                       |
| Serrated type 2 (knife-edge thin)  | 294.9 a          | 10.44 a                | 1.988 ab           | 0.07039 ab                      |
| Flat type (knife-edge flat)      | 234.50 b         | 8.299 b                | 1.783 b            | 0.06307 b                       |
| Mean                             | 277.73            | 9.83                    | 1.969              | 0.06969                          |
| LSD                              | 12.49             | 0.442                   | 0.222              | 0.0102                          |
| Knife cutting angle (°)          |                   |                        |                    |                                 |
| 0                               | 319.3 a           | 11.30 a                | 2.393 a            | 0.08464 a                       |
| 10                              | 311.5 a           | 11.07 a                | 2.147 a            | 0.07596 ab                      |
| 20                              | 256.1 b           | 9.063 b                | 1.834 b            | 0.06946 bc                      |
| 30                              | 252.2 b           | 8.913 b                | 1.794 b            | 0.06349 bc                      |

e-ISSN: 2148-2683
### 4. Conclusions

The significant differences were found between the knives types at a 1% probability level. The best results were determined at the flat knife type, followed by serrated 2 and serrated 1, respectively. While the lowest cutting force and cutting strength values were obtained at flat type (knife edge flat) as 234.50 N, 8.299 MPa, 1.783 J and 0.06730 J mm⁻² respectively, the highest values cutting forces, cutting strength, cutting energy and specific cutting energy were obtained at serrated type 1 (knife edge thin) knife as 303.8 N, 10.75 MPa, 2.136 J and 0.075610 J mm⁻² respectively.

The cutting force, cutting strength, cutting energy and specific cutting energy decreased with increasing knife-cutting angle from 0° to 40°. The maximum cutting force, cutting strength, cutting energy and specific cutting energy were observed at 0° cutting angle as 319.3 N, 11.30 MPa, 2.393 J and 0.08464 J mm⁻² respectively. The lowest values were obtained at 20°, 30° and 40° cutting angle.

The effect of the knife loading speed on the cutting forces, cutting strength, cutting energy and specific cutting energy were found significant statistically (p<0.01). The lowest cutting force, cutting strength, cutting energy and specific cutting energy were obtained at the 1 m s⁻¹ as 246.1 N, 8.705 MPa, 1.273 J and 0.04502 J mm⁻² respectively.

### Acknowledgments

This study was carried out with the test machine that the buy a project supported by the Scientific Research Funding (DUBAP-08-ZF-59) of Dicle University. The authors would like to thank Dicle University for providing the Material Test Machine and financial support.
References

Alizadeh, M.R., Ajdadi, F.R., Dabbaghi, A. 2011. Cutting energy of rice stem as influenced by internode position and dimensional characteristics of different varieties. AJCS 5(6), 681-687.

Allameh, A., Alizadeh, M.R. 2016. Specific cutting energy variations under different rice stem cultivars and blade parameters. Idesia (Arica), 34(5), 11-17.

Amer Essa, A.H., Gomaa, A.H., Baiomy, M.H., Ibrahim, A.A. 2008. Physical and mechanical characteristics for some agricultural residues. In Misr J Ag Eng, 25(1), 121–146.

Asabe Standards (2008). S358.2: 1: Measurement Forages. 52nd edn. American Society of Agricultural Engineers, St Joseph MI.

Azadbakht, M., Esmaeilzadeh, E., Esmaeili-Shayan, M. 2015. Energy consumption during impact cutting of canola stalk as a function of moisture content and cutting height. Journal of the Saudi Society of Agricultural Sciences (2015) 14, 147–152.

Chandio, F.A., Changying, J., Tagar, A.A., Mari, A.I., Guangzhao, T., Cuong, D.M. 2013. Comparison of mechanical properties of wheat and rice straw influenced by loading rates. African Journal of Biotechnology Vol. 12(10), 1068-1077.

Chen, Y., Gratton, J.L., Liu, J. 2004. Power requirements of hemp cutting and conditioning. Biosystems Engineering, 87(4), 417-424.

Dange, A.R., Thakare, S.K., Rao, I.B. 2011. Cutting energy and force as required for Pigeon pea stems. Journal of Agricultural Technology 2011 Vol. 7(6), 1485-1493.

Ekinci, K., Yilmaz, D., Ertekin, C. 2010. Effects of moisture content and compression positions on mechanical properties of carob pod (Ceratonia siliqua L.). African Journal of Agricultural Research, 5(10), 1015–1021.

Esgici, R., Ozdemir, G., Pekitkan, F.G., Elicin, A.K., Ozturk, F. and Sessiz, A. 2017. Some engineering properties of the Sire grape (Vitis Vinifera L.). Scientific Papers-Series B-Horticulture, vol. 61, 195–203.

Gan, H., Mathanker, S, Momin, M.A., Kuhns, B., Stoffel, N., Hansen, A., Grift, T. 2018. Effects of three cutting blade designs on energy consumption during mowing-conditioning of Miscanthus Giganteus. Biomass and Bioenergy, ISSN: 0961-9534, Vol: 109, Page: 166-171.

George, D.M.R., Smith, A.C., Waldron, K.W. 2001. Effect of ripening on the mechanical properties of Portuguese and Spanish varieties of olive (Olea europaea L). Journal of the Science of Food and Agriculture J. Sci. Food. Agric. 81, 448-454.

Ghahraei, O., Ahmad, D., Khalina, A., Suryanto, H., Othman, J. 2011. Cutting tests of kenaf stems. Transactions of the ASABE, 54(1), 51-56.

Heidari, A., Chegini, G.R. 2011. Determining the shear strength and picking force of rose flower. Agricultural Engineering. Ejpau 14(2), 13.

Igathinathane, C., Womac, A.R., Sokhansanj, S. 2010. Corn stalk orientation effect on mechanical cutting. Systems engineering 107, 97–106.

Jasim, A.A., Abbood, M.R., Abbood, S.M. 2017. Effect of knives type on some operational characteristics for a locally assembly motorized vibration cutter used for Date Palm fronds pruning. International Journal of Environment, Agriculture and Biotechnology (IJEB) Vol.2(4), 1597-1600.

Khazaei, J., Rabani, H., Ebadi, A., Golbabaei, F. 2002. Determining the shear strength and picking force of pyrethrum flower. AIC Paper No. 02-221.

Khodaei, J., Akhijahani, H.S. 2012. Some physical properties of Rasa grape (Vitis vinifera L.). World Applied Sciences Journal 18(6), 818-825.

Kocabiyik, H., Kayisoglu, B. 2004. Determination of shearing features of sunflower stalk. In J Agric Sci, vol. 10, 2004, no. 3, 263–267.

Kronbergs, A., Širaks, E., Kronbergs, A.E. 2011. Mechanical properties of hemp (cannabis sativa) biomass. Environment. Technology. Resources. Proceedings of the 8th International Scientific and Practical Conference. 1, 184-190.

Kusińska, E., Starek, A. 2012. Effect of knife wedge angle on the force and work of cutting peppers. Teka. Commission of Motorization and Energetics in Agriculture – 2012, Vol. 12, No. 1, 127–130

Mathanker, S.K., Grift, T.E., Hansen, A.C. 2015. Effect of blade oblique angle and cutting speed on cutting energy for energycane stems. Biosystems Engineering, Vol.133, 64-70.

Mohsenin, N.N. 1986. Physical properties of plant and animals materials. 2nd edition. New York, NY: Gordon and Breach Science Publishers.

Morris, J.R. 2000. Past, present, and future of vineyard mechanization. Proceeding ASEV 50 the Anniv. Ann. Mtg. Seattle, WA, 51, 155-164.
Nandede, B.M., Raul, A.K., Singh, D., Jadhav, M.L., Solanke, K.R. 2017. Effect of blade type, diameter and moisture content of Sorghum stalk and earhead on cutting energy. Multilogic in Science, Vol.7(24), 38-40.

Nowakowski, T. 2016. Empirical model of unit energy requirements for cutting giant miscanthus stalks depending on grinding process parameters. Annals of Warsaw University of Life Sciences – SGGW, Agriculture (Agricultural and Forest Engineering) 67, 63–70.

Ozdemir, G., Sessiz, A., Esigi, R., Elicin, A.K. 2015. Cutting properties of wine grape cultivars. Scientific Papers. Series B, Horticulture. Vol. LIX, 151-158.

Ozdemir, G., Sessiz, A., Pekitkan, F.G. 2017a. Precision viticulture tools to production of high quality grapes. Scientific Papers. Series B, Horticulture. Vol. LXI, 2017, June 8-10, Bucharest, Romania.

Ozdemir, G., Sessiz, A., Esigi, R. 2017b. Some maturity properties of Okuzgozu (Vitis Vinifera L. CV.) grape berries. Fresenius Environmental Bulletin. Volume 28, No:10, 6261-6265.

Pekitkan, F.G., Esigi, R., Elicin, A.K., Sessiz, A. 2018. The change of shear force and energy of cotton stalk depend on knife type and shear angle. Scientific Papers. Series A. Agronomy, Vol. LXI, No. 1, 360-366.

Persson, S. (1987). Mechanics of cutting plant material. ASAE Publications, St Joseph, MI, USA.

Prasad, J., Gupta, C.B. 1975. Mechanical properties of maize stalks as related to harvesting. J Agric Eng Res, vol. 20, 1975, no. 1, 79–87.

Romano, E., Bonsignore, R., Camillieri, D., Caruso, L., Conti, A., Schillaci, G. 2010. Evaluation of hand forces during manual vine branches cutting. International Conference Ragusa SHWA, September 16-18, 2010 Ragusa Ibla Campus- Italy. Work Safety and Risk Prevention in Agro-Food and Forest Systems.

Sessiz, A., Elicin, A.K., Esigi, R., Ozdemir, G., Nozdrovický, L. 2013. Cutting properties of olive sucker. Acta Technologica Agriculturae. The Scientific Journal for Agricultural Engineering, The Journal of Slovak University of Agriculture in Nitra. 16(3), 80–84.

Sessiz, A., Esigi, R., Ozdemir, G., Elicin, A.K., Pekitkan, F.G. 2015. Cutting properties of different grape varieties. Agriculture & Forestry, 6(1), 211-216.

Singh, V., Das, M., Das, S.K. 2016a. Effect of varying knife speed and contact area on peak cutting force during slicing of peeled potato (Solanum tuberosum). International Food Research Journal 23(6), 2513-2518.

Singh, V., Das, M., Das, S.K. 2016b. Effects of knife edge angle and speed on peak force and specific energy when cutting vegetables of diverse texture. International Journal of Food Studies IJFS, Vol.5, 22-38.

Sushilendra, Veerangouda, M., Anantachar, M., Prakash, K.V., Desai, B.K., Vasudevan, S.N. 2016. Effect of blade type, cutting velocity and stalk cross sectional area of chickpea stalks on cutting energy, cutting force and specific energy. International Journal of Agriculture Sciences, Vol.8(53), 2658-2662.

Taghijarah, T., Ahmadi, H., Ghahtderjani, M., Tavakoli, M. 2011. Shearing characteristics of sugar cane (Saccharum officinarum L.) stalks as a function of the rate of the applied force. AJCS 5(6), 630-634.

Voicu, G., Moiceanu, E., Sandu, M., Poenaru, I.C., Voicu, P. 2011. Experiments regarding mechanical behaviour of energetic plant Miscanthus to crushing and shear stress. In Engineering for Rural Development Jelgava, 26.

Yiljep, Y., Mohammed, U. 2005. Effect of knife velocity on cutting energy and efficiency during impact cutting of Sorghum stalk. Agricultural Engineering International: The CIGR EJournal. Manuscript PM 05 004. Vol. VII. December, 2005.

Yore, M.W., Jenkins, B.M., Summers, M.D. 2002. Cutting properties of rice straw. Paper Number: 026154.ASAE Annual International Meeting / CIGR XVth World Congress.

Zareiforoush, H., Mohtasebi, S.S., Tavakoli, H., Alizadeh, M.R. 2010. Effect of loading rate on mechanical properties of rice (Oryza sativa L.) straw. Australian Journal of Crop Science, 4(3), 190–195.