Determination of Sugar Beet Topping Slice Thickness by Using Image Analysis Technique

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Abstract: One of the most important processes of sugar beet harvest is topping process. If topping quality is not good enough, sugar and weight losses can be seen. Because of this reason topping quality in accordance with standards has economical value.

In this research image analysis technique was examined for developing topping quality with an automatic topping unit at domestic sugar beet harvesting machines. Projection areas, head diameter values and volume values of sugar beets were determined for this purpose. Topping quality relations of these values were also determined. Regression coefficient was obtained as 85,8% from relationship between ideal topping thickness and sugar beet top view area. Regression coefficient between image analysis topping thickness and sugar beet top view area was also estimated as 83,9 %.

Key words: Sugar beet, sugar beet harvesting, image analysis

INTRODUCTION

Sugar beet head can be specified as a section between the top sides of the beet to the beginning of the leaves. Harmful N rate is found in very high amount at sugar beet heads which cause sugar crystallization during fabrication. Because of this reason, heads of the beets do not include any technological value. As a result, factories wants producer to cut the beets head before buying the beets. Topped sugar beet heads is an important animal nutrition with good nutritional source to animal.

Sugar beet contains sugar less than sugar cane but even though, it is important and strategically agricultural product. Sugar beet processing industry is a complex structure and the product must be best suited to this complex structure in which features of this product not to be in problem. Sugar beet harvest in the fields by using harvesting machines occurs with minimal losses and this harvest method prevents deterioration of the quality of product.

Today harvest operations are done by sugar beet harvesting machines because of high operating speed needs, allowable level post-harvesting mechanical damage to meet factory standards and low level post-

harvest sugar losses. Turkey is ranking 6th at sugar beet production in the world (Anonymous, 2009). According to TSI 2008 data, 3716 sugar beet harvest machine is available in Turkey (TSI, 2010). Manufactures of domestic production of sugar beet harvest machines has led to the development of the spare parts industry.

Topping process takes half of all harvest time between harvest processes like digging, collecting, cleaning and loading. Because of this reason topping process is the most important process of sugar beet harvest (Colak, 1990). Topping process can be done before or after harvest by using harvesters.

There are three different harvest methods for harvesting sugar beets and these are classified as one level harvest with combine harvesting machines, two level harvest and three level harvest (Colak, 1986). At single-level harvest all harvesting operations are performed with a harvesting machine, at two-level harvest topping and removal of leaves are performed with two different machines, at three-level harvest topping, digging and collecting operations are performed by three different machines. Today most of

the harvesters cut top of the beets before harvest. These harvesters have the same basic working principles. At the same time they have some constrictive differences at their topping units.

Basically topping units have a topper, knives which connected to the topper and link arms (Fig. 1). The most frequently used topping equipment includes a passive copier and a passive cutter in worldwide (Bulgakov, 2002). As work principles, knife cuts beet heads according to position of tapper while harvesting machine on operation.

Slice thicknesses can be adjusted by chancing of tapper and knife distance. Generally slice thicknesses remains constant while working at most of the harvesters. Some of harvester producers have developed and used topping units which takes position according to beet diameter and height above ground. But success of this mechanisms changes according to head diameters and height above ground of different sugar beet varieties.

Different beet diameters and growing differences cause errors and effect the change of slice thickness of beets at the field. Slice thickness is set up according to average value of slice thickness of beets at most of the harvesters. Otherwise, different beet heads are cut from wrong place because of deviation of the diameters during operation. Because of this reason, harvesters need topping tolerance. Appropriate place considered to be topping between the bottoms of the green leaves and the lowest dried leaves.
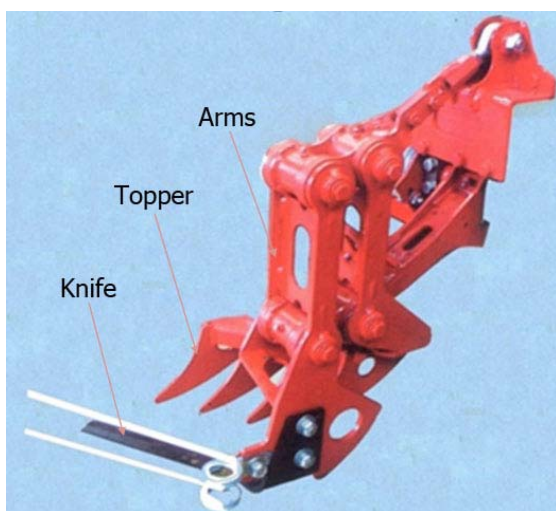
Topping losses can be seen due to not to cut off the beets, over cutting, inadequate cutting and curve cutting. Maximum diameter, height above the ground, beet distances at the rows and height of the beets at the same rows affects topping quality while harvesting by harvest machines. If deviation of the beet diameter is over from the average beet diameters topping unit does not cut good enough at big and little beets.

Dilution and misfire is not enough at the field as beet diameters change at the same row. In this case, little beets have low heights above the ground. At this time, if big beets in the same row with little beets, harvest unit cannot cut little beets because of topper position at the big beets. Additionally, if distances of the beets at the same row are different from topping unit crushes the head of beets and breaks the heads.

In this research, the aim is to increase topping quality of domestic sugar beet that harvested by machines using image analysis technique. Projection areas, head diameter values and volume values of sugar beets and topping quality relations of this values all were determined for this aim.

MATERIAL and METHOD
Material

We can list the general characteristics of sugar beet field located in Polatlı province at Ankara in the following way; sugar beet rate of the field is 36000 sugar beet/ha, average sugar beet rate 8000 sugar beet/ha, sugar beet distance between at the same row 25 cm, distance between the rows 45 cm. 135 sugar beets were harvested for experiments from the field. Average of measurements of the beets which have been harvested from the field in Polatlı have been given in table 1.

Table 1. Technical measurements of the sugar beets.

Feature	Unit	Average Value
Maximum beet diameter	mm	130±25
Beet top height above the ground	mm	40±10
Beet length	mm	217±55
Bulk density of sugar beets	kg/m³	1.0±0.10
Average sugar beet weight	g	1324±610

Nikon D40X model digital camera with a tripod was used for taking top view of sugar beets. Digital photos

Figure 1. Sample of parallelogram topping unit

of sugar beets have been taken with 5x8 cm size calibration plate then objects were selected correctly at the software. Photo samples of the sugar beets which taken into consideration were given in Figure 2.

Figurel 2. Top view sample photo of a sugar beet

Myriad v8.0 image analysis software was used for determining technical dimensions and measurements (Figure 3).
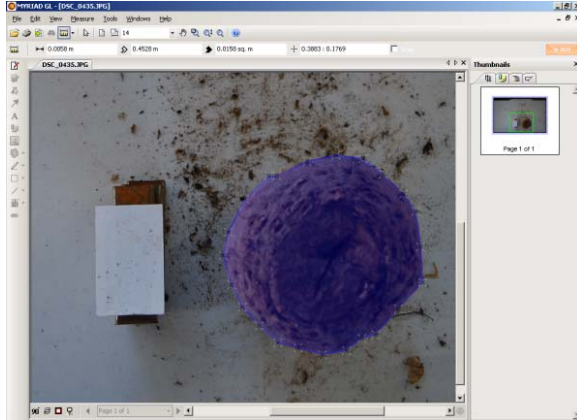

Figure 3. Interface of digital image analysis software Myriad v8.0

This program has two steps for measuring images. First step was calibration of the program. For this purpose, software needs a calibration ruler or a calibration plate. Second step is true and direct selection of images (Beyaz et al., 2009).

Method

Projection areas, head diameter values and volume values of sugar beets and topping quality relations of this values were determined by using formulas indicated between 1-5 (Colak et al., 1994).

$$x = 0,439 \times D_s \qquad (1)$$

$$a = 0,74 \times D_s \qquad (3)$$

$$b = 0,349 \times D_s \qquad (4)$$

$$V_c = \frac{1}{3}\pi ab \cdot x + 3a \qquad (5)$$

Here;

x: Ideal topping thickness (mm),

D_s: Beet diameter (mm),

a: Upper side of topping region (mm),

b: Lower side of topping region (mm),

V_T: Beet value (mm^3),

V_c: Topped slice volume (mm^3).

Obtained data was analyzed by using Minitab statistical analysis software. Estimation equations and regression coefficients were given in results and discussions section.

RESULTS and DISCUSSION

Regression coefficient between ideal topping thickness and sugar beet top view area was found to be 85,8 % as shown in Figure 4. This is an acceptable regression coefficient for determining ideal topping thickness. This regression coefficient shows us topping distance adjustment limits can be determined in narrower ranges instead of average topping distance limits. The 10 mm shifting from topping distance cause 10% product loss. Selling sugar beet topping with losses as animal nutrition instead of the sugar factory provides 50% less income.
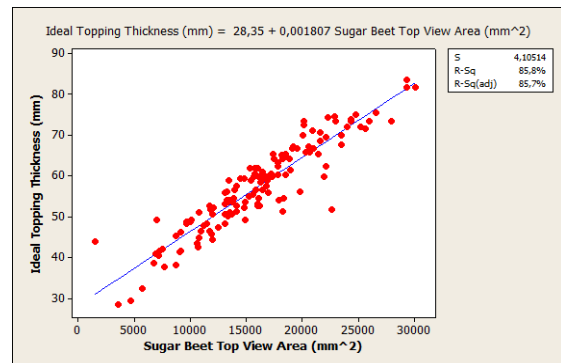

Figure 4. Ideal topping thickness - sugar beet top view area regression coefficient graph

Regression coefficient between image analysis topping thickness and sugar beet top view area were evaluated as 83,9 % as shown in Figure 5. The results which obtained from image analysis is similar with the

results shown in figure 4. It means that we can use image analysis technique instead of evaluation method for determining ideal topping thickness. Similarly (Beyaz et al., 2009), the image analysis method was tested on Kahramanmaras red pepper (*Capsicum annuum* L.) which is not shaped properly. For this purpose the front, top and left side of each peppers were taken for evaluations. Projection areas were determined from these images. Then effects of each image and image combinations were able to determine the volume. The most appropriate estimation formula was found from the top and the left projection. This formula has been given 89.7% with regression coefficient for estimation of volume.
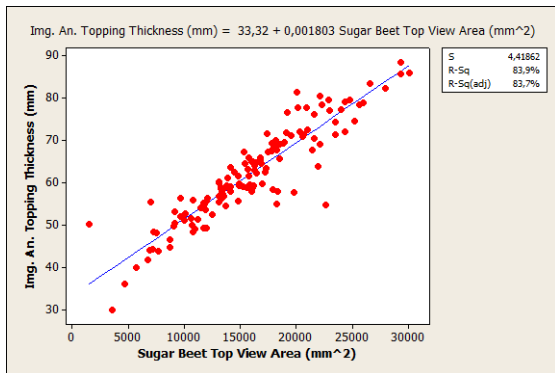

Figure 5. Image Analysis topping thickness - sugar beet top view area regression coefficient graph

Regression coefficient between topping slice volume and ideal topping thickness were evaluated 98,4 % as seen in Figure 6. This result shows us there is high correlation between slice volume and ideal topping thickness. This proofs that the deep topping cause economic losses of sugar beet and sugar.
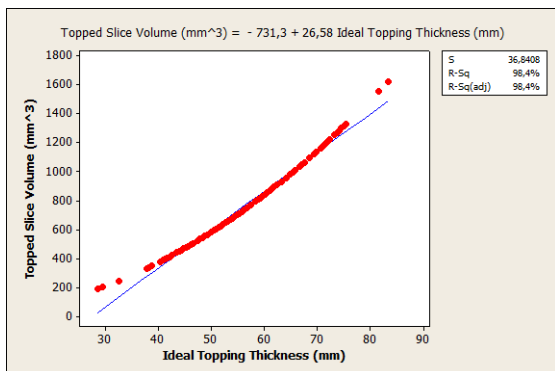

Figure 6. Topping slice volume - ideal topping thickness regression coefficient graph

Regression coefficient between image analysis topping slice volume and ideal topping thickness were evaluated 94,2 % as shown in Figure 7. The results which obtained from image analysis show similar with the results shown in Figure 6.
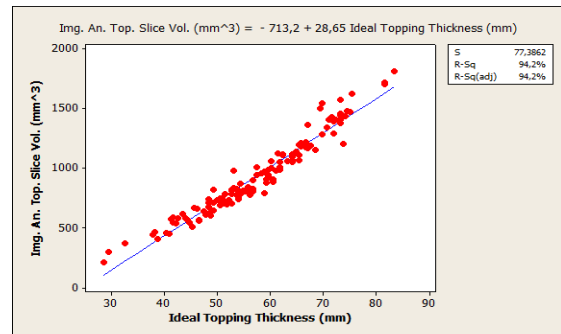

Figure 8. Image Analysis topping slice volume - ideal topping thickness regression coefficient graph

Regression coefficient between sugar beet volume and ideal topping thickness was evaluated 76,2 % as shown in Figure 8.
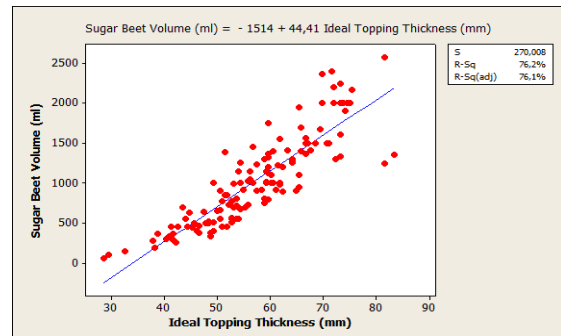

Figure 8. Sugar beet volume - ideal topping thickness regression coefficient graph

Regression coefficient between sugar beet volume and image analysis sugar beet diameter was evaluated 70,7 % as shown in Figure 9.
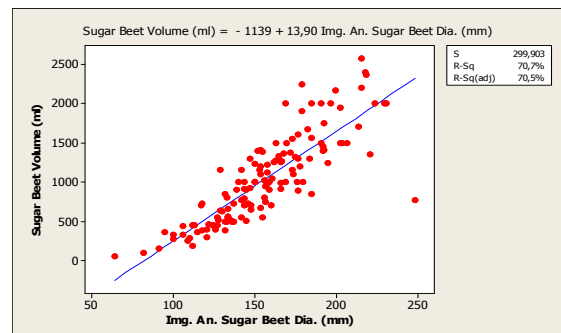

Figure 9. Sugar beet volume – image analysis sugar beet diameter regression coefficient graph

The results of this research can help any machine designer for developing electronically image analysis systems for determining ideal topping thickness.

All developments like new topping units or new mechanisms help us to protect and improve product quality. At the same time harvesters help us to meet factory needs. All kinds of harvesters makes easy harvest process, improves product and work quality. Especially all kind of developments at the topping units, knives and tappers effects and improve industrial product quality. The result of this research shows us that an image analysis based electronic system can be effective way more than average slice thickness system. By this way topping slice distances can be adjusted automatically for each beet head in different field and condition. The success of the harvest machines can be improved and new topping units can be designed with image analysis technique for decreasing topping losses.

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