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Comparison Kultivator Duck-Foot Shares in Respect of Hardness and Wear Rates

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Abstract
Agricultural tools are under the influence of abrasive particles in the soil. Under this influence, there is a process going from erosion to deformation and even breakage. In this process, various factors have an effect. The major factor is that the physical and chemical properties of the material do not conform to the standards. In this study, wear and hardness values of 5 kultivator duck-foot shares were measured. A simulation model was developed for the wear value, and the changes of the samples taken from the endmills after 10 hours of soil erosion were determined in grams. The received samples are named X, Y, Z, Q, W respectively. The wear rates (%) were found to be 4.03, 2.2, 2.27, 3.14, 2.69 respectively. Among these results, the highest wear was observed in X, the least wear was seen in Y. The hardness measurement scale is brinell hardness number. On each specimen, 10 values of hardness were measured from different points and their mean values were found. Average hardness values (HB) were found as (X, Y, Z, Q, W) (101, 233, 164, 125, 158) respectively. As a result, it has been determined that the wear values are inversely proportional to the material hardness values.

Key Words: Kultivator, Duck-foot shares, Wear rates (%), Hardness

Kültivatör Kazayağı Uç Demirlerinin Aşınma Oranı ve Sertlik Bakımından Karşılaştırılması

Öz
Toprak içerisinde çalışan tarım aletleri toprağın aşındırıcı partiküllerinin etkisi altında kalmaktadır. Bu etki altında aşınmaya, deforme olmaya ve hatta kırılmaya kadar giden bir süreç yaşanmaktadır. Bu süreçte çeşitli faktörlerin etkisi vardır. Bu faktörlerin başında malzemenin fiziksel ve kimyasal özelliklerinin standartlara uygun olmaması gelmektedir. Bu çalışmada, 5 adet kültivatör kazayağı uç demirinin aşınma ve sertlik değerleri ölçülmüştür. Aşınma değeri için bir simülasyon modeli geliştirilerek uç demirlerinden alınan numunelerin 10 saatlik toprak içi aşınma sonrasında değişimleri gram cinsinden belirlenmiştir. Alınan numuneler sırasıyla X,Y,Z,Q,W olarak isimlendirilmiştir. Aşınma oranları (%) sırasıyla 4.03, 2.2, 2.27, 3.14, 2.69 olarak bulunmuştur. Bu sonuçlar içerisinde en fazla aşınma X'de, en az aşınma Y'de görüldü. Sertlik ölçümü brinell cinsinden yapılmıştır. Her numune üzerinde farklı noktalardan 10'ar tane sertlik ölçüm değeri alınmış ve bunların ortalama değerleri bulunmuştur. Ortalama sertlik değerleri (HB) sırasıyla (X,Y,Z,Q,W) (101, 233, 164, 125, 158) olarak bulunmuştur. Bu sonuçlar içerisinde sertliği en fazla olan Y, en az sertliğin ise X'de olduğu tespit edilmiştir. Sonuç olarak aşınma değerlerinin malzeme sertliği değerleri ile ters orantılı olduğu saptanmıştır.

Anahtar Kelimeler: Kültivatör, Kazayağı uç demiri, Aşınma oranı (%), Sertlik

Introduction

We can say as soil working equipment 1th grade soil working equipment (plow, chisel and subsoiler) and 2nd grade soil working equipment (kultivator, rake, soil/rotary cultivator, rollers and other tools) which is used in agricultural machinery. All these soil working equipment are subjected to deformation, stretching, abrasion, etc. in various sizes during work. In particular, soil-working parts are exposed to deformation by abrasive particles of the soil. As a result, undesirable conditions are observed such as deterioration, cracking, abrasion or breakage. This both causes the part running in the soil to fail to work and interrupt the working. Spakale et al. (2016) stated that different material characteristics are related to abrasive wear or have some effects on abrasive wear and noted that these characteristics of the materials as the composition of the material, yield stress, elastic modulus, hardness.

The biggest and most important problem encountered in the use of soil working equipment and machine is their short duration of active abrasions that come into direct contact with the soil. They can not performed their duty due to wear. The ability of soil working equipment to fulfill their duties at the desired level is largely in direct proportion to the quality of their active organs. (Şenay, 2013). Particular attention should therefore be paid to the manufacture of parts which are subject to such continuous wear. Otherwise, the part will break down in a much shorter period of time than desired. In order to minimize such problems caused by wear, both standard should be followed and the work should be weighted to reduce wear. In the article of Çakmak (2001), the discotic disc root obtained from Erdemir 5040 alloy curing steel was heat treated at 950 ^{0}C curing temperature and at different annealing temperatures and measured the wear values in the field. Palalı (2007) tested ploughshare which was made of ERD-5630 steel, at sandy-clayey-loamy soil at 5-8 kmH-1 speed by coating with chromium, nickel and titanium nitride. As a result, they found that the wear of the coated material was later. Anappa and Basavarajappa (2013) observed that the ploughshare showed more resistance to sheet erosion wear when it was coated with the ZEDALLOY VB surface leveling electrode. Mohsenin and Womochel, (2005) have investigated the wear rates of various carbon contents and different alloy properties in the ploughshare by using a wheel-type abrasion tester rotating in a laboratory environment. Although hardness seem to decrease wear, it is pointed that there is no correlation between them. The duck-foot which composed of kultivator share are also a part of the soil of which working it inside. The duck-foot wear out rapidly due to the physical structure of the soil (hardness, stiffness, etc.) that is lead to loses its function. Korucu and Arslan (2008) examined that the effect of different kultivator shares on the pulling force of the abrasion and speed of tractor advance during operation. As a result of the study, it was indicated that the increase in speed of tractor pace increased pulling force and that it was difficult to sink to the ground with the increase of the tip wear in which they pointed out that the depth of the work was not smooth. Gupta et al. (2004) observed different types of duck-foot and weight loss using field tests in order to determine wear value and compared the results obtained. Güleç (2012) study carried out the chemical analysis, tensile test, hardness test and microscopic texture analyzes of the duck-foot and narrow shares by the kultivator manufacturers in Amasya and Çorum provinces around Tokat and compared the results with the relevant Turkish standards. As a result, It is suggested that the companies that produce kultivator shares should use materials in accordance with the standards and the establishment of the expert team and laboratory environment and follow up the developing technology so that the tests of these materials can be done. Cingöz (2008) stated that the materials used in manufacturing should be suitable for agricultural applications and that agricultural equipment and machines using materials with appropriate technical characteristics will have a longer life.

There is TS 2384 standard which entered into force in 2016 by the TSE Authority regarding the duck-foot shares. However, standards are generally not followed. Generally, manufacturers uses railway lining, scrap iron, and materials manufactured at the market called 1040 steel materials as raw material of shares.

In this study to be carry out, we will determine the conformity of the kultivator shares to the standards and the wear values at different times. As a result, it is thought that it will give light to the work done later. Because, as a result of this study, ,m order to the material can be made longer and It is foreseen that boron coating can be carried out or that the thickness of the meat of the produced material is thicker or that the different alloy elements of the material should be involved. Thus, our study will lead to research and studies to be carried out in this direction.

Materials and Methods

Cultivator Shares

The kultivator duck-foot shares which was used in the kultivators produced and sold in study was obtained from 5 different places. The shares used in the trial are shown in Figure 1.

Figure 1. Kultivator duck-foot shares
Şekil 1. Kültivatör kazayağı uç demirleri

The schematic picture of the shares are shown in Figure 2.

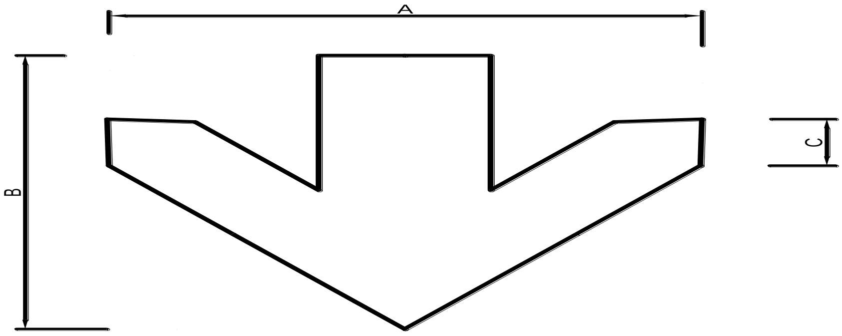

Figure 2. The Schematic picture of the duck-foot shares
Şekil 2. Kazayağı uç demirlerinin şematik resmi

Table 1. The measurements of the *duck-foot shares*
Çizelge 1. Kazayağı uç demirlerinin ölçüleri

A (mm)	B (mm)	C (mm)	Weight (Ağırlık) (g)
145	140	12*12	450-500

Precision Balance

In our work, we used a precision scale with a precision of 0.001 gr to determine the loss of weight in the sample, at the end of wear. The weight is an important parameter in determining how much will wear samples taken from the kultivator shares after the work is done.

Figure 3. Precision balance
Şekil 3. Hassas terazi

Hardness Tester

Hardness values, material fragility, elasticity etc. are an important criterion for many of the materials used in the industry. It is important to know the hardness values of the parts working in the soil especially in agricultural machinery. Accuracy of Time 5100 Portable Hardness Tester is ±6HLD (760 ±30HLD). In this study, TIME 5100 brand manual metal hardness tester is used which shown in Figure 4.

Figure 4. Manual metal hardness tester
Şekil 4. Manuel metal sertlik cihazı

Columnar Drill Workbench

The samples taken from the duck-foot shares were welded to the nuts and mounted on the drill bit. Wear was then carried out by mounting on a drill table with a column and rotating at the desired cycle and speed.

Soil

In order to carry out the wear of the duck-foot shares, firstly a steel vessel of a certain size was provided and then soil was added inside. In addition, soil analysis was performed. Soil is set to as loamy soil. The results of soil analysis are shown in Table 2.

Table 2. Soil analysis results
Çizelge 2. Toprak analiz sonuçları

ph	EC	Lime	Organic matter	P (ppm)	K. (meg/100g)
8.06	217	61.75	2.14	40.25	0.65
Ca (meg/100g)	Na (meg/100g)	Mg (meg/100g)	Clay (%)	Sand (%)	Plate (%)
7.74	0.1133	1.91	34.66	37.51	27.82

Humidiometer

The amount of moisture in the soil is an important factor for the process to be performed. As the amount of moisture increases, the material that is working in the soil will be strained and working will become difficult. In addition to the difficulty of working, wear, abrasion and deformation will occur in material. At the same time, fuel consumption will increase and the cost of production will increase. Therefore, the humidity for all samples is set to 4%. The device is presented in Figure 5.

Figure 5. Soil moisture measuring device
Şekil 5. Toprak nemi ölçüm cihazı

Results and Discussion

Detection of Wear on Shares

Five different types of samples used in the experiment were subjected to 10 hours of operation in the soil pool in the prepared experimental unit. The studies were paused for 1 hour and sample weight measurements were detected at each pause and data were taken. In addition, first the average wear value at the nut and in the welding material was determined. This value was subtracted from the final measurements to detect wear in the original material. The shares which is shown in figure 6 are used in the study. The wear values are shown in Table 3.

Figure 6. Sample duck-foot shares used in experiments
Şekil 6. Deneylerde kullanılan numune kazayağı uç demirleri

Table 3. Wear values in the samples
Çizelge 3. Numunelerdeki aşınma değerleri

Values *Değerler*	X (g)	Y (g)	Z (g)	Q (g)	W (g)
Initial *Başlangıç*	44.6	41.1	61.5	54.0	55.7
1. Pause *1.Duraklama*	44.5	41.0	61.3	53.8	55.5
2. Pause *2.Duraklama*	44.3	40.8	61.1	53.6	55.3
3. Pause *3.Duraklama*	44.2	40.7	61.0	53.5	55.1
4. Pause *4.Duraklama*	44.0	40.6	60.9	53.3	54.9
5. Pause *5.Duraklama*	43.8	40.5	60.7	53.1	54.8
6. Pause *6.Duraklama*	43.6	40.4	60.6	53	54.6
7. Pause *7.Duraklama*	43.4	40.2	60.5	52.8	54.5
8 . Pause *8.Duraklama*	43.2	40.1	60.4	52.6	54.4
9 . Pause *9.Duraklama*	43.0	40.0	60.2	52.5	54.3
Final *Son*	42.8	39.9	60.1	52.3	54.2

Mean (%) Weight Losses in Samples

To find out the weight loss that's happening in the samples, the weight loss (%) was found from the values in Table 3 using the first and last wear values. The following formula is used for this.

Mean Wear Rate (%)

$$= \frac{\text{First Weight (g)} - \text{Final Weight (g)}}{\text{First Weight (g)}} * 100 \quad (1)$$

Using the above formula, the following Table 4 was obtained.

Table 4. Mean wear values (%) in the samples

Tablo 4. Numunelerdeki (%) ortalama aşınma oranları

Sample Numune	First weight İlk ağırlık (g)	Final weight Son ağırlık (g)	Mean wear rates (%) Ortalama aşınma oranı (%)
X	44.6	42.8	4.03
Y	40.8	39.9	2.20
Z	61.5	60.1	2.27
Q	54.0	52.3	3.14
W	55.7	54.2	2.69

Using Table 4, the following Figure 7 is obtained. When we look at wear rates, we see that wear is at X with 4.03%, followed by Q, W, Z, Y respectively. Also the mean hardness (HB) values in the samples were calculated to compare these wear rates with the hardness values.

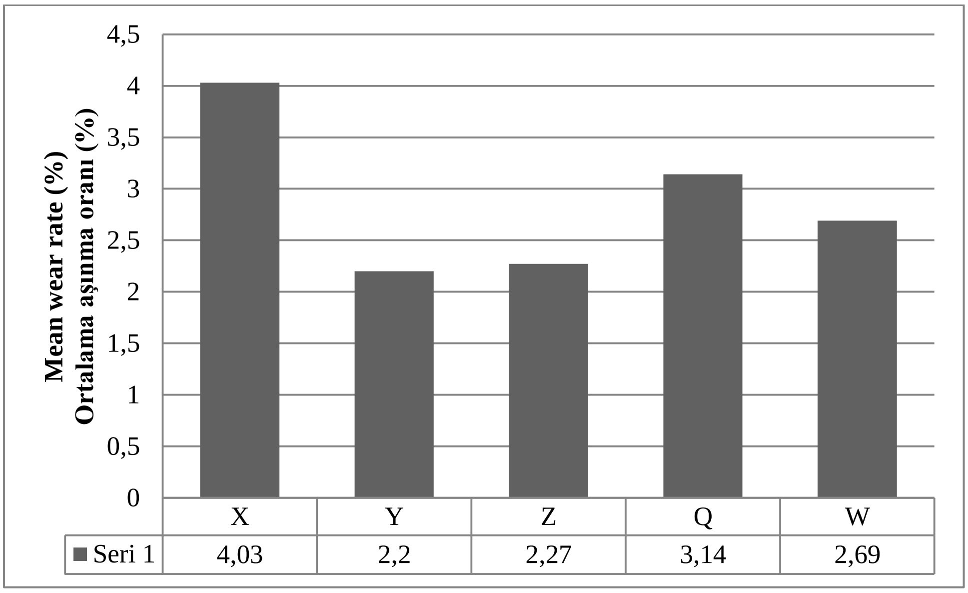

Figure 7. Mean wear values (%) in the samples

Şekil 7. Numunelerdeki (%) ortalama aşınma oranları

Hardness Measurement Values

To obtain the hardness values in the samples, different measurements were taken for each sample from 10 different points and after which averages of these values were found. Hardness measurements were made in Brinell (HB). The obtained values are presented in Table 5.

Table 5. Hardness measurement values
Tablo 5. Sertlik ölçüm değerleri

Values Değerler	X (HB)	Y (HB)	Z (HB)	Q (HB)	W (HB)
1. Value 1. Değer	108	310	177	134	157
2. Value	114	336	216	127	169
3. Value	88	142	152	129	213
4. Value	133	256	108	114	156
5. Value	124	121	108	124	158
6. Value	91	234	196	133	137
7. Value	81	214	141	134	124
8. Value	82	276	167	125	149
9. Value	83	191	185	117	154
10. Value	106	250	190	112	163
Mean values Ortalama değerler	101	233	164	125	158

Figure 8 is obtained according to the average values obtained from Table 5. As shown in Figure 8, the hardest material is the Y sample with 233 HB. This is followed by Z, W, Q, X respectively.

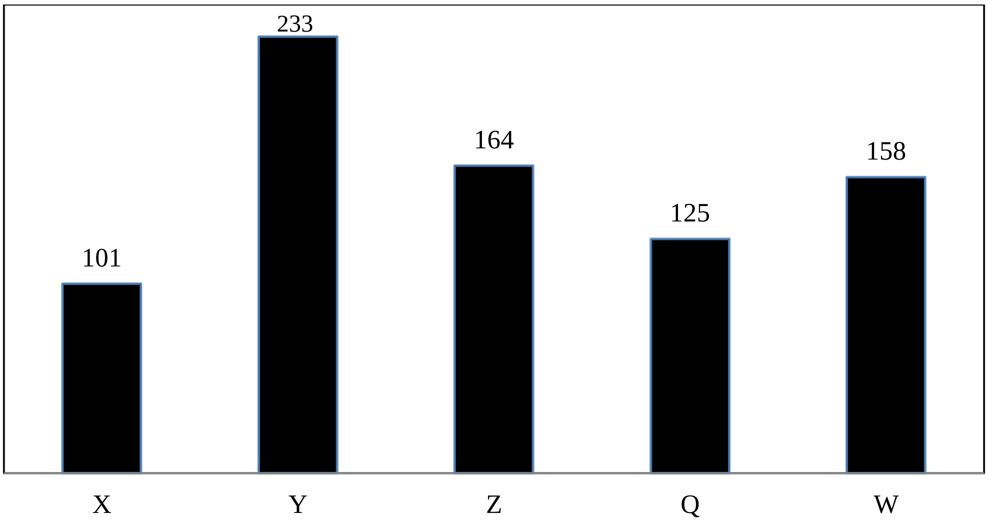

Figure 8. Mean hardness values(HB)
Şekil 8. Ortalama sertlik ölçüm değerleri (HB)

Comparison of the Wear Values (%) and Hardness Measurement Values (HB)

In general agricultural equipment and machinery working in the soil are subject to wearing in certain quantities due to impact of soil and other particles in it. There are many criteria that affect the extent to which it will wear out. We can say this as the type of wear (abrasive, adesive, erosion, static, dynamic etc.) and the properties of the material (elasticity, hardness, heat treatment, type of material, etc.). In the comparison between the wear rates (%) and the hardness values obtained in our study, a graph was obtained as shown in Figure 9.

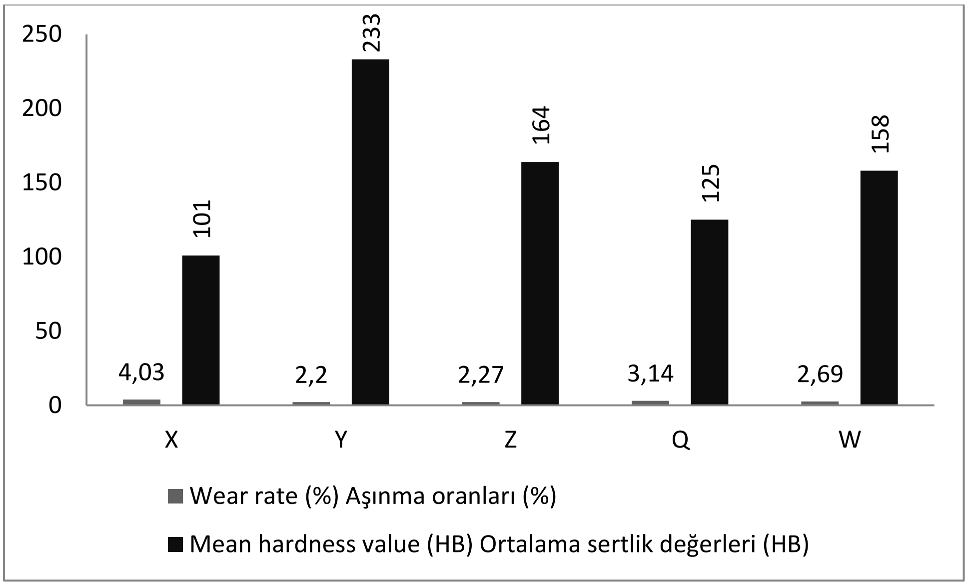

Figure 9. Comparison of the hardness and wear values
Şekil 9. Sertlik ve aşınma değerlerinin karşılaştırılması

In Figure 9, on the Y sample, where the hardness is the greatest, the least wear has occurred. For the other samples, there is an inverse ratio between hardness and wear rate. That is, as the hardness increases, the amount of wear from the material decreases. Babacan et al. (2003) have investigated how blades used in stalk cutter behave in field trials and as a result, they found less wear in materials with high hardness.

Conclusion

With the development of today's industry, metals and alloys are being used much more in the industry. One of the most used places in the industry is the agricultural mechanisation. Parts used in agricultural mechanisation, especially machines working in soil, are also subject to wear more rapidly than other parts which brings economic damage to the national economy and consumers. Therefore, the materials used must be standard and used in accordance with the appropriate soil cultivation techniques. These materials which were made in accordance with the standards have a long lifetime.

As a result of the hardness and abrasion tests of the 5 types of kultivator shares that we have studied, we obtained the following findings.

1) For the X sample, the hardness value was determined as mean 101 HB,

the amount of wear of the material was determined as 4.03%. Because of the lowest hardness value the most wear carried out in this sample.

2) For the X sample, the hardness value was determined as mean 233 HB, the amount of wear of the material was determined as 2.2%. Because of the lowest hardness value the most wear carried out in this sample.

3) For the Z sample, the hardness value was determined as mean 164 HB, the amount of wear of the material was determined as 2.27%. An inverse ratio was also determined in the same way between the hardness value and the wear rate (%).

4) For the Q sample, the hardness value was determined as mean 125 HB, the amount of wear of the material was determined as 3.14%. An inverse ratio was also determined in the same way between the hardness value and the wear rate (%).

5) For the X sample, the hardness value was determined as mean 158 HB, the amount of wear of the material was determined as 2.69%. An inverse ratio was also determined in the same way between the hardness value and the wear rate (%).

Cultivator shares, which are used in agricultural production, are usually produced in small workshops. Generally, it is not taken into consideration whether the materials produced conform to the standards. In Production should pay attention to the following points.

- Coatings of different surface with wear resistant,

- Using of steels which manufactured in accordance with the standards,

- Does not to use scrap and train linings in production,

- Using the tempered steel,

- Making the necessary heat treatments in accordance with the standards,

- Manufacturing companies should allocate sufficient time for the necessary research and development before production,

- Performing the necessary tests in accordance with the standards,

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