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# DIMENSION, GEOMETRIC, AGRICULTURAL AND QUALITY CHARACTERISTICS OF SAFFLOWER SEEDS

*Rahim ADA[1*]*

[1]*Selcuk University,Faculty of Agriculture, Department of Field Crops, Konya, TURKEY*
[*]*Corresponding author: rahimada@selcuk.edu.tr*

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**ABSTRACT**

**This research was carried out in the research field of Agricultural Faculty, Selcuk University, Konya, Turkey. Field experiments were carried out in two growing seasons (2011 and 2012) according to "Randomized Complete Block Design" with three replications. In the study, a total of 13 promised safflower (*Carthamus tinctorius* L.) lines (A13, A29, C12, E12, F4, F5, F6, G16, H3, J19, Y1-8-14-1, AOL-2(2), DP 1.5.8-1) and 5 cultivars (Black Sun1, KS 06 and Oleic Leed, Dinçer, Remzibey) were used as material. Oil content of the safflower genotypes were ranged in between 24.05-33.18%. The highest protein content value was obtained from J19 line (21.72%) while the lowest was found on the Turkish cultivar of Remzibey (16.03%). Negative correlations were found for oil content and hull thickness (r=-0.3152**), hull ratio (r=-0.7122**) and pappus ratio (r=-0.3408**). Protein content was found as significantly and negative correlated with some characters, similar to the seed widness (r = -0.2546**), seed thickness (r=-0.1918*), geometric diameter (r=-0.3194**), seed surface area (r=-0.3119**), pappus ratio (r=-0.3114**) and 100-seed weight (r=-0.2597), respectively. According to the results, increasing the dimension and geometrical values cause to a decrease in the oil and protein content of safflower seeds. Quality components (oil and protein content) showed negative correlations with both of pappus rate and hull features.**

**Keywords: *Carthamus tinctorius*, dimension, hull, oil, protein, Safflower seed**

## INTRODUCTION

Safflower is a member of the family Asteraceae, it is cultivated primarily for achene (seed), which is used as oil and birdseed. Flowers are known to have many medical properties (Dajue and Mundel, 1996) and cut flowers (Uter, 2008). The leaves, shoots of safflower are also used for salad (Nimbkar, 2002).

Number of drought resistant crops such as safflower should be increased over the world. (Singh and Nimbkar, 2007). Although Turkey is not a big part in the world safflower seed production, areas under safflower seed cultivation have recently increased (Sacilik et al., 2007).

In the former researches, safflower breeders typically focused on the yield, quality and resistance breeding, etc. characteristics (Urie and Zimmer, 1970; Urie, 1986; Singh et al., 2008; Ada, 2012). However, there is necessary to improvement of the genotypes which are convenient to the demand of industry. According to Tarighi et al. (2010), it is necessary to understand the physical features of safflower in order to develop equipment for sowing, harvesting, and storage and oil extraction of safflower seeds. The dimensions of safflower are important in design of separating and grinding in the machines.

Researchers (Sadeghi et al., 2011; Kaya et al., 2011) put forth interesting results about the relationship between dimension and seed germination properties. Therefore, the best way to know the properties of safflower seeds has multiple benefits. This study was in Konya-Turkey conditions during the both years of 2011 and 2012 and, the seed characteristics of the safflower cultivars and lines were determined.

## MATERIALS AND METHOD

In the study, a total of 13 safflower promised lines (A13, A29, C12, E12, F4, F5, F6, G16, H3, J19, Y1-8-14-1) which were selected and collected from Konya natural vegetation and 2 lines (AOL-2(2), DP 1.5.8-1) obtained by pedigree method and breeded by Dr. Rahim ADA, and 3 American cultivars (Black Sun1, KS 06 and Oleic Leed), 2 Turkey cultivars (Dinçer, Remzibey) were used, seeds were produced in the research field of Agricultural Faculty , Selcuk University, Konya, Turkey in two growing seasons (2011 and 2012). The study was conducted on 4$^{th}$ of April 2011 and 05$^{th}$ of April 2012 according to "Randomized Complete Block Design" with three replications. Each genotype was sown in plots with 4 rows, 4 m of longitude with spacing 50 cm between rows.

In the both years of 2011 and 2012 the amounts of total precipitations between April and August were 201.3 and 66.8 mm respectively. Average temperature was 18.3ºC and 20.6ºC in the first and the second vegetation periods. The soil was clay loam, with pH 8.03, and there was not any salinity problem.

In the experiments, a total of 40 kg ha$^{-1}$ of $P_2O_5$ and 30 kg ha$^{-1}$ of nitrogen were applied before sowing and 20 kg ha$^{-1}$ of nitrogen (ammonium nitrate 33%) was used as a top fertilizing during starting of stem elongation. Weeds were controlled by hand.

The seeds were cleaned manually to remove all foreign matter such as chaff as well as immature and broken seeds. The three linear dimension of the seeds (Figure 1), namely length (L), widness (W) and thickness (T) were measured using a micrometer (0.01 mm of sensitivity) (Baumler et al., 2006).

Geometric mean diameter (Dg) and sphericity (Ø) values were found using the following formula (Mohsenin, 1970; Calisir et al., 2005):

$$Dg = (LWT)^{1/3}$$

$$Ø = (LWT)^{1/3}/L$$

where: L is the length, W is the widness and T is the thickness, all the data were recorded as mm unit.

The seed surface area of safflower was found by analogy with a sphere of same geometric mean diameter, using the following expression cited by Sacilik et al. (2003).

$$S = \pi Dg$$

where s is the surface area in mm$^2$ and Dg is the geometric mean diameter in mm.

Hull percentage, oil (Soxhlet) and protein (Kjeldahl) analysis made according to Keles (2010).

Analysis of correlation (JUMP, SAS Institute Inc. 1989-2002) and variance (MSTAT-C, Michigan State University, 1983) were performed using statistical software packages.

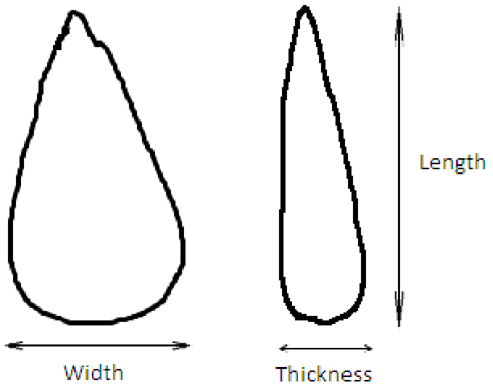


**Figure 1.** Linear dimension of safflower

## RESULTS

The differences among the genotypes were significant for all seed characteristics (Table 1 and 2).

**Table 1.** Some seed characteristics of safflower genotypes (2011 and 2012)

| Genotypes of safflower | Seed Length (mm) | Seed Widness (mm) | Seed Thickness (mm) | Geometric Mean Diameter (mm) | Sphericity (%) | Seed Surface Area (mm$^2$) | Hull Thickness (mm) | Hull Ratio (%) | Pappus Ratio (%) | 100-Seed Weight (g) | Oil Content (%) | Protein Content (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dinçer** | 7.27$^{a-d}$ | 3.78$^{cd}$ | 3.14$^{fg}$ | 4.42$^{e-h}$ | 0.607$^{ef}$ | 61.24$^{efg}$ | 0.397$^{ab}$ | 51.37$^{c-g}$ | 1.45$^{e}$ | 3.63$^{ef}$ | 26.29$^{efg}$ | 17.17$^{e-h}$ |
| **Remzibey** | 6.86$^{b-e}$ | 3.97$^{bcd}$ | 3.25$^{d-g}$ | 4.46$^{b-h}$ | 0.650$^{bcd}$ | 62.38$^{c-g}$ | 0.362$^{abc}$ | 48.49$^{fgh}$ | 10.62$^{abc}$ | 3.36$^{fgh}$ | 29.30$^{cd}$ | 16.03$^{h}$ |
| **Black Sun1** | 7.10$^{a-e}$ | 3.91$^{bcd}$ | 3.21$^{efg}$ | 4.46$^{b-h}$ | 0.629$^{cde}$ | 62.54$^{b-g}$ | 0.357$^{bcd}$ | 43.39$^{ij}$ | 1.66$^{de}$ | 3.42$^{fgh}$ | 31.44$^{ab}$ | 19.53$^{bc}$ |
| **KS 06** | 7.54$^{ab}$ | 4.14$^{bc}$ | 3.27$^{c-g}$ | 4.68$^{a-d}$ | 0.621$^{cde}$ | 68.85$^{a-e}$ | 0.353$^{bcd}$ | 42.74$^{j}$ | 2.06$^{de}$ | 4.02$^{abc}$ | 33.18$^{a}$ | 17.30$^{e-h}$ |
| **Oleic Leed** | 6.51$^{e}$ | 3.78$^{cd}$ | 3.29$^{b-g}$ | 4.32$^{fgh}$ | 0.665$^{ab}$ | 58.73$^{fg}$ | 0.315$^{d}$ | 40.51$^{j}$ | 1.15$^{e}$ | 3.26$^{gh}$ | 32.47$^{a}$ | 19.32$^{bc}$ |
| **A13** | 7.40$^{abc}$ | 4.06$^{bcd}$ | 3.63$^{a}$ | 4.77$^{a}$ | 0.646$^{bcd}$ | 71.68$^{a}$ | 0.361$^{abc}$ | 52.52$^{b-e}$ | 14.50$^{ab}$ | 4.15$^{a}$ | 26.28$^{efg}$ | 17.55$^{d-g}$ |
| **A29** | 7.49$^{abc}$ | 4.07$^{bcd}$ | 3.43$^{a-e}$ | 4.71$^{ab}$ | 0.629$^{cde}$ | 69.74$^{a-d}$ | 0.385$^{ab}$ | 53.65$^{bcd}$ | 16.42$^{a}$ | 4.10$^{ab}$ | 25.91$^{f-i}$ | 17.91$^{def}$ |
| **C12** | 7.07$^{a-e}$ | 4.33$^{ab}$ | 3.47$^{a-d}$ | 4.73$^{a}$ | 0.670$^{ab}$ | 70.34$^{ab}$ | 0.397$^{ab}$ | 55.39$^{ab}$ | 10.57$^{bc}$ | 3.79$^{b-e}$ | 24.86$^{ghi}$ | 17.16$^{e-h}$ |
| **E12** | 6.97$^{a-e}$ | 4.03$^{bcd}$ | 3.31$^{b-g}$ | 4.53$^{a-g}$ | 0.650$^{bcd}$ | 64.30$^{a-g}$ | 0.328$^{cd}$ | 47.27$^{hi}$ | 5.27$^{cde}$ | 3.18$^{h}$ | 30.33$^{bc}$ | 16.39$^{gh}$ |

The seed length, widness and thickness of the used genotypes are shown in the Table 1 and 2 show. The highest value for seed length (7.64 mm), widness (4.73 mm) and thickness (3.63 mm) were observed at J19, F4 and A13 safflower lines. The lowest seed length, widness and thickness were recorded from Oleic Leed (6.51 mm), AOL-2(2) (3.57 mm) and H3 (3.09 mm).

There were significant differences among different safflower genotypes in terms of the parameters of geometric mean diameter, sphericity and seed surface area. Geometric mean diameter, sphericity and seed surface area were ranged from 4.25 -4.77 mm, 0.589-0.693 % and 56.82-71.68 mm$^2$ respectively on safflower genotypes.

The highest hull thickness and ratio in the safflower genotypes were obtained from H3 (0.402 mm) and F4 (58.52 %) lines, whereas Oleic Leed cultivar (0.315 mm and 40.51 %%) resulted with the lowest values.

**Table 2.** Some seed characteristics of safflower genotypes (2011 and 2012) (continue)

| Genotypes of safflower | Seed Length (mm) | Seed Widness (mm) | Seed Thickness (mm) | Geometric Mean Diameter (mm) | Sphericity (%) | Seed Surface Area ($mm^2$) | Hull Thickness (mm) | Hull Ratio (%) | Pappus Ratio (%) | 100-Seed Weight (g) | Oil Content (%) | Protein Content (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F4 | 6.79$^{cde}$ | 4.73$^{a}$ | 3.34$^{b-g}$ | 4.70$^{abc}$ | 0.693$^{a}$ | 69.98$^{abc}$ | 0.381$^{ab}$ | 58.52$^{a}$ | 10.55$^{bc}$ | 3.41$^{fgh}$ | 24.36$^{hi}$ | 16.98$^{fgh}$ |
| F5 | 7.03$^{a-e}$ | 4.12$^{bc}$ | 3.51$^{abc}$ | 4.66$^{a-e}$ | 0.664$^{ab}$ | 68.35$^{a-d}$ | 0.368$^{abc}$ | 49.48$^{e-h}$ | 5.15$^{cde}$ | 3.86$^{a-e}$ | 27.99$^{de}$ | 16.72$^{fgh}$ |
| F6 | 7.11$^{a-e}$ | 4.05$^{bcd}$ | 3.53$^{ab}$ | 4.66$^{a-e}$ | 0.656$^{bc}$ | 68.22$^{a-e}$ | 0.388$^{ab}$ | 51.55$^{b-g}$ | 4.65$^{de}$ | 3.56$^{efg}$ | 24.95$^{ghi}$ | 18.27$^{cde}$ |
| G16 | 7.05$^{a-e}$ | 3.87$^{bcd}$ | 3.23$^{d-g}$ | 4.45$^{c-h}$ | 0.632$^{b-e}$ | 62.27$^{c-g}$ | 0.388$^{ab}$ | 52.35$^{b-f}$ | 6.80$^{cde}$ | 3.40$^{fgh}$ | 27.16$^{ef}$ | 16.66$^{fgh}$ |
| H3 | 6.61$^{d-e}$ | 3.77$^{cd}$ | 3.09$^{g}$ | 4.25$^{h}$ | 0.643$^{bcd}$ | 56.82$^{g}$ | 0.402$^{a}$ | 52.67$^{b-e}$ | 3.30$^{de}$ | 3.21$^{h}$ | 24.08$^{i}$ | 21.72$^{a}$ |
| J19 | 7.64$^{a}$ | 4.02$^{bcd}$ | 3.39$^{a-f}$ | 4.71$^{ab}$ | 0.617$^{def}$ | 69.58$^{a-d}$ | 0.368$^{abc}$ | 50.48$^{d-h}$ | 6.88$^{cde}$ | 3.95$^{a-d}$ | 26.58$^{efg}$ | 18.59$^{bcd}$ |
| Y1-8-14-1 | 6.65$^{de}$ | 3.74$^{cd}$ | 3.18$^{efg}$ | 4.29$^{gh}$ | 0.646$^{bcd}$ | 57.80$^{f-g}$ | 0.391$^{ab}$ | 55.18$^{abc}$ | 7.41$^{cd}$ | 2.66$^{i}$ | 26.20$^{e-h}$ | 19.22$^{bc}$ |
| AOL-2(2) | 7.54$^{ab}$ | 3.57$^{d}$ | 3.25$^{d-g}$ | 4.44$^{d-h}$ | 0.589$^{f}$ | 61.88$^{d-g}$ | 0.388$^{ab}$ | 47.70$^{gh}$ | 2.63$^{de}$ | 3.78$^{cde}$ | 31.76$^{ab}$ | 19.60$^{b}$ |
| DP 15-8-1 | 6.99$^{a-e}$ | 4.08$^{bcd}$ | 3.30$^{b-g}$ | 4.55$^{a-f}$ | 0.651$^{bc}$ | 65.15$^{a-f}$ | 0.354$^{bcd}$ | 49.24$^{efg}$ | 1.45$^{e}$ | 3.65$^{def}$ | 27.85$^{de}$ | 18.39$^{b-e}$ |
| Mean | 7.10 | 3.99 | 3.33 | 4.55 | 0.642 | 64.99 | 0.371 | 50.14 | 6.25 | 3.58 | 27.83 | 18.02 |
| Mean Square | 0.68194** | 0.39838* | 0.12513** | 0.16345** | 0.00354** | 134.336** | 0.00353* | 129.701** | 129.501** | 0.87228** | 50.6486** | 12.5621** |
| LSD Value | 0.7186 | 0.5411 | 0.2511 | 0.2586 | 0.03871 | 7.908 | 0.04746 | 3.953 | 5.814 | 0.3174 | 1.841 | 1.283 |

** $p < 0.01$, * $p < 0.05$

With respect to pappus ratio, the A 29 line (16.42%) had the highest value, while the lowest value were obtained from Oleic leed (1.15%), Dinçer (1.45%) cultivar and DP 15-8-1 (1.45%) line.

100-seed weight of safflower genotypes were ranged from 2.66 to 4.15 g. The highest 100-seed weight was recorded from A13 line, whereas the lowest 100-seed weight was recorded from Y1-8-14-1.

Safflower genotypes had significant effect on the oil content (p<0.01). Oil ratios were varied from 24.05% to 33.18%. America originated cultivars were in the same group as statically; KS 06 (33.18%) and Oleic Leed (32.47%) had the highest oil content, whereas H3 (24.08%) had the lowest ratio.

Differences among the safflower genotypes were found as significant for protein content. The highest protein content value was obtained from H3 line (21.72%) while the lowest was found from the Turkish cultivar Remzibey (16.03%).

Correlation coefficients among the studied safflower seed characteristics were given in Table 3, 4 and 5. Negative correlations were found among oil content and hull thickness (r=-0.3152**), hull ratio (r=-0.7122**) and pappus ratio (r=-0.3408**) (Table 4).

Protein content was significant but negatively correlated with the fallowing characters; seed widness (r = -0.2546**), seed thickness (r=-0.1918*), geometric mean diameter (r=-0.3194**), seed surface area (r=-0.3119**), pappus ratio (r=-0.3114**) and 100-seed weight (r=-0.2597), respectively (Table 5).

## DISCUSSION

Oil content of achene (seed) is a very important economic character for safflower genotypes and considered one of the most important factors affecting the success of safflower production in different regions (Vorpsi et al., 2010). Similarly, the oil-cake meal resulting from pressing the oil from the seed is being offered as a feed for livestock under the name whole pressed safflower seed meal (Goss and Otogaki, 1954). Therefore, plant breeders should focus on the physical properties of safflower seeds which are adapted to the design of equipment for handling, storing, dehulling and processing. These safflower properties are affected by numerous factors such as size and form features of the achene (seed) (Baumler et al., 2006).

Earlier studies which were investigated for different humidity levels seed length, widness, thickness and geometric mean diameter and sphericity were reported as it seen in the fallowing line: Aktas et al. (2006) found 7.27-7.81 mm, 3.50-3.79 mm, 2.80-3.50 mm, 4.46-4.84 mm and 47.14-48.83 % respectively, Calisir et al. (2005) 6.89-7.56 mm, 3.76-4.36 mm, 2.71-3.19 mm, 4.13-4.70 mm and 60.00-62.30% respectively and seed surface area was found by Seifi et al. (2010) as a value of 65.63-79.15 $mm^2$, Tarighi et al., (2010) reported as 57.2-70.38 $mm^2$ and Tarighi et al. (2011) found 62.77-72.38 $mm^2$. It is well known that there is a positive correlation between 100-seed weight and seed yield in safflower (Singh et al., 2008). This feature (seed yield) is quite important for manufacturers. In terms of 100-seed weight, a similar result with the present research was reported by Arslan et al. (2008) with a range from 3.86 g to 4.82 g.

**Table 3.** Correlation coefficients of the seed characteristics

| Variable | by Variable | Correlation |
|---|---|---|
| Seed Widness | Seed Length | 0,0487 |
| Seed Thickness | Seed Length | 0,2029* |
| Seed Thickness | Seed Widness | 0,2087* |
| Geometric Mean Diameter | Seed Length | 0,5089** |
| Geometric Mean Diameter | Seed Widness | 0,7706** |
| Geometric Mean Diameter | Seed Thickness | 0,6537** |
| Sphericity | Seed Length | -0,5533** |
| Sphericity | Seed Widness | 0,7057** |
| Sphericity | Seed Thickness | 0,4068** |
| Sphericity | Geometric Mean Diameter | 0,4340** |
| Seed Surface Area | Seed Length | 0,4832** |
| Seed Surface Area | Seed Widness | 0,7975** |
| Seed Surface Area | Seed Thickness | 0,6385** |
| Seed Surface Area | Geometric Mean Diameter | 0,9984** |
| Seed Surface Area | Sphericity | 0,4606** |
| Hull Thickness | Seed Length | 0,0240 |
| Hull Thickness | Seed Widness | 0,0496 |
| Hull Thickness | Seed Thickness | -0,0313 |
| Hull Thickness | Geometric Mean Diameter | 0,0215 |
| Hull Thickness | Sphericity | -0,0077 |
| Hull Thickness | Seed Surface Area | 0,0271 |
| Hull Ratio | Seed Length | -0,0695 |
| Hull Ratio | Seed Widness | 0,0973 |
| Hull Ratio | Seed Thickness | 0,0088 |
| Hull Ratio | Geometric Mean Diameter | 0,0407 |
| Hull Ratio | Sphericity | 0,1112 |
| Hull Ratio | Seed Surface Area | 0,0477 |

**Table 4.** Correlation coefficients of the seed characteristics (continue)

| Variable | by Variable | Correlation |
|---|---|---|
| Hull Ratio | Hull Thickness | 0,2967** |
| Pappus Ratio | Seed Length | 0,1408 |
| Pappus Ratio | Seed Widness | 0,3161** |
| Pappus Ratio | Seed Thickness | 0,3421** |
| Pappus Ratio | Geometric Mean Diameter | 0,4086** |
| Pappus Ratio | Sphericity | 0,2412* |
| Pappus Ratio | Seed Surface Area | 0,4166** |
| Pappus Ratio | Hull Thickness | 0,1021 |
| Pappus Ratio | Hull Ratio | 0,3763** |
| 100-Seed Weight | Seed Length | 0,6316** |
| 100-Seed Weight | Seed Widness | 0,2591** |
| 100-Seed Weight | Seed Thickness | 0,3730** |
| 100-Seed Weight | Geometric Mean Diameter | 0,5927** |
| 100-Seed Weight | Sphericity | -0,0948 |
| 100-Seed Weight | Seed Surface Area | 0,5740** |
| 100-Seed Weight | Hull Thickness | 0,1213 |
| 100-seed weight | Hull Ratio | -0,0880 |
| 100-Seed Weight | Pappus Ratio | 0,1746 |
| Oil Content | Seed Length | 0,0857 |
| Oil Content | Seed Widness | -0,0745 |
| Oil Content | Seed Thickness | -0,1627 |
| Oil Content | Geometric Mean Diameter | -0,0931 |
| Oil Content | Sphericity | -0,1722 |
| Oil Content | Seed Surface Area | -0,0955 |
| Oil Content | Hull Thickness | -0,3152** |
| Oil Content | Hull Ratio | -0,7122** |
| Oil Content | Pappus Ratio | -0,3408** |

**Table 5.** Correlation coefficients of the seed characteristics (continue)

| Variable | by Variable | Correlation |
|---|---|---|
| Oil Content | 100-Seed Weight | 0,0944 |
| Protein Content | Seed Length | -0,1311 |
| Protein Content | Seed Widness | -0,2546** |
| Protein Content | Seed Thickness | -0,1918* |
| Protein Content | Geometric Mean Diameter | -0,3194** |
| Protein Content | Sphericity | -0,1660 |
| Protein Content | Seed Surface Area | -0,3119** |
| Protein Content | Hull Thickness | 0,0411 |
| Protein Content | Hull Ratio | -0,0311 |
| Protein Content | Pappus Ratio | -0,3114** |
| Protein Content | 100-Seed Weight | -0,2597** |
| Protein Content | Oil Content | -0,0885 |

Some of the safflower genotypes had pappus but, this characteristic is not a desirable (Dajue and Mundel, 1996). In this study, while pappus percentage especially in developed safflower lines with a selection of natural vegetation varied between 3:30 to 16:42%, commercial cultivars determined between 1.15 and 10.62%.

The oil content in the released genotypes was varying from 28 to 30%, which needs an increase of 5–8% in this crop (Yadava et al., 2012). In order to increase the content of oil seeds, plant breeders have attempted to reduce the testa tissue through breeding selection. Moreover, knowledge of characteristics of the seed testa is imperative. For this purpose, the reduction of sclerenchyma varies from seed to seed (Urie and Zimmer, 1970).

Baumler et al. (2006) worked on hull thickness and they reported the results between 0.282-0.407 values in different humidity levels. A well-developed hull (achene) cause to a reduction of 30% in oil content. Thickness of hull should be less than 50% in safflowers (Dajue and Mundel, 1996). Therefore, as the thick Hull tends to keep the oil content in safflower low, reduction of the Hull increases oil percentages (Dajue and Mundel, 1996) and meal quality (Urie and Zimmer, 1970).

Percentage of the Hull is an important component affecting the oil content (Weiss, 2000; Baumler et al., 2006) and environmental and other non-genetic factors may influence Hull content (Urie 1986). According to De Silva and Gordon (1986), if a high negative genotypic correlation exists between hull content and susceptibility, it may be difficult to select for recombinants favorable in both traits. Oil content of safflower genotypes varies between 54.3% and 58.4%. Uysal et al (2006) found these values as 52.0-54.2%, Keles and Ozturk (2012) found as 38.26-45.31%. Safflower seeds are rich of protein content, hence it is valuable in animal feeding. For this reason, protein content in safflower is one of the important quality criteria.

The protein values obtained in this study gave similar results with the reports of Doğan and Serinc (1990) (17.62-24.22%), Keles and Ozturk (2012) (17.13-19.76%) and also Ada (2012) 24.04-28.79%.

## CONCLUSION

According to the results, increasing in the dimension and geometrical values caused to decreasing in the content of oil and protein in the safflower seeds. Pappus rate and quality requirements (oil and protein content) showed a negative correlation while, there was a positive correlation between hull characteristics and pappus.

Consequently, plant breeders should focus on the mentioned characteristics and pappus for seed selection.

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