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ESTIMATION OF SOYBEAN SEEDS WEIGHT USING IMAGE PROCESSING

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Abstract: Today, image processing techniques are frequently used in irrigation, fertilization and spraying applications in order to increase agricultural input efficiency and product quality. In this study, the relationship between the image and weight of soybeans was investigated. For this purpose, some image processing applications were carried out on the images of soybeans grown with the deficit irrigation (100%, 75, 50 and 25) method. In the study, the relationship between the weight of soybeans and the number of pixels occupied on the images was 88.78%. The weights belonging to the displayed soybean grains decreased from 100% watered to 50% watered, in the 25% irrigated area, it increased again. The 25% irrigated case created significant stress for soybeans. However, as in some plants, this situation caused an increase in grain weight in soybeans.

Keywords: Image processing, HSV color space, Soybean

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1. Introduction

Soybean (*Glycine max*. L.), a one-year warm climate plant belonging to the legume family, is used in human and animal nutrition and has a high nutritional value (Sahar, 2017). Its seeds contain an average of 36-40% protein, 18-24% fat, 26% carbohydrates and 18% mineral matter, and about 20% of the world's vegetable oil production is met by soybeans (Arioglu, 2007). Soybean protein has the closest protein to animal protein and has a high biological value (Seckin Dinler and Tasci, 2020). Soybean can be grown for grain, dry hay and silage, can be used as a cover crop for erosion control and as a green fertilizer that adds nitrogen to the soil (Acikgoz et al., 2013). After itself, soybean, which is included in the crop rotation, has an important potential for sustainable agriculture due to its increased yield in the products to be sown and its fertilizer savings, both economically and ecologically, providing positive contributions to the soil (Agin and Malasli, 2016; Ozel and Acar, 2020). Water stress is an effective factor that limits the production of this important plant in semi-arid and semi humid regions of the world. In these regions, the frequency and amount of precipitation during the growing season is usually quite variable. Under non-irrigated conditions in humid areas, the variability in seasonal rainfall leads to variability in water and nutrient uptake, as well as growth, development, and yield from year to year (Scott et al., 1987; Sincik et al., 2008).

Growing soybean is economically feasible in places where there is water and low irrigation costs, however, water stress caused by limited irrigation in places where water is not available significantly reduces seed yield and components of soybean (Scott et al., 1987; James, 1988; Karam et al., 2005; Sincik et al., 2008; Candogan, 2009; Turgut, 2021). Water stress has different effects on plants depending on the period. If water stress is applied at the beginning of flowering period in soybean, it can reduce the number of pods in the plant, while in the flowering period it can cause a decrease in the number and size of pods. If water stress is applied during the pod filling period, it can negatively affect the size of the seeds (Oya et al., 2004; Candogan, 2009; Turgut, 2021).

Thanks to the advances in computer technology, one of the fields of application that has a very wide scope is image processing (Balci et al., 2016; Demir et al., 2016). The advantages of image processing such as providing more accurate and reliable results than traditional methods, being fast and economical at the same time, have enabled its widespread use (Balkir et al., 2019). In agricultural production, different image processing applications are carried out from the sowing process to the obtaining of the products and then the determination of their quality, size, weight, etc. characteristics. The processing of any image data generally involves (1) reading the images by an image processing program (Image Acquisition), (2) performing some preprocessing (changing image size, color space transformations, normalization, etc.) to eliminate distortions and noise in the images (Preprocessing), (3) extracting information such as color and shape from the image (Feature

Extraction), (4) classifying the extracted information from the image to recognize objects (Classification) (Pedreschi et al., 2004; Rzanny et al., 2017). Image processing is widely used in agricultural applications such as color analysis of agricultural products, quality control, classification, detection of weeds, spraying and automation processes in agriculture. Many studies have been conducted in this field (Kilic et al., 2007; Chen et al., 2010; Sabanci et al., 2012; Cai et al., 2013; Sofu et al., 2013; Paap, 2014; Sabanci and Aydin, 2014; Rahman et al., 2015; Demir et al., 2016; Yilmaz, 2016; Karadol, 2017; Sert, 2018; Sharif et al., 2018; Solak and Altinisik, 2018; Turkoglu et al., 2020).

In this study, the aim was to estimate the weight of the pods based on the area they occupy on the image with the limited irrigation method for soybean seeds. The results obtained were compared with the real weight and the success rate of the system was calculated and an effective method was presented for the soybean quality value.

2. Materials and Methods

In the study, soybeans produced in a total of 12 parcels with three repetitions of irrigation, 100% irrigation, 75% irrigation with 25% deficit of 100% irrigation, 50% irrigation with 50% deficit of 100% irrigation, and 25% irrigation with 75% deficit of 100% irrigation, were used to meet the plant's needs.

The soybeans collected from the parcels were divided into groups and 80 soybeans were selected for each group. The 12 bean groups were then randomly placed on an A4 paper. Afterwards, images of the soybeans were obtained from a CMOS sensor type cell phone camera with a resolution of 64 MP at a distance of 40 cm. The images obtained in RGB format were then processed in the MATLAB environment using the following steps.

1. The region of interest (ROI) was determined and cropped out from the RGB image.
2. The resulting new image was converted from the RGB color space to the HSV color space.
3. The "saturation" channel in the HSV color space was converted to a binary image using a static threshold value due to its ability to separate the soybeans more clearly from the gray level value.
4. The noises on the binary image were cleaned using a small-valued structural element and the total area values (total pixel count) of the regions (soybeans) with white color values on the image were recorded. Images related to these processes are shown in Figure 1.

3. Results

The number of pixel counts and weights of soybean groups on the image are shown in Table 1 and the change states of these two values are shown in Figure 2. When the irrigation rate was reduced from 100% to 50%, the average pixel count and weight of the bean groups decreased. At 25% irrigation rate, both the weight and total pixel count increased. As in some plants, it is understood that soybean also causes grain growth and weight gain as a result of the plant's exposure to water stress. The relationship between total pixel counts and weights belonging to images of soybean seed groups is given in Figure 3. The actual weights of the 12 manually separated soybean seeds were determined with 88% accuracy across all irrigation method using the total number of pixels they occupied on the image. For production purposes only to obtain seed weight without taking into account quality and nutritional content, 25% irrigation can be recommended. However, to make a definite conclusion on this, the number of experiments on this subject needs to be extended.

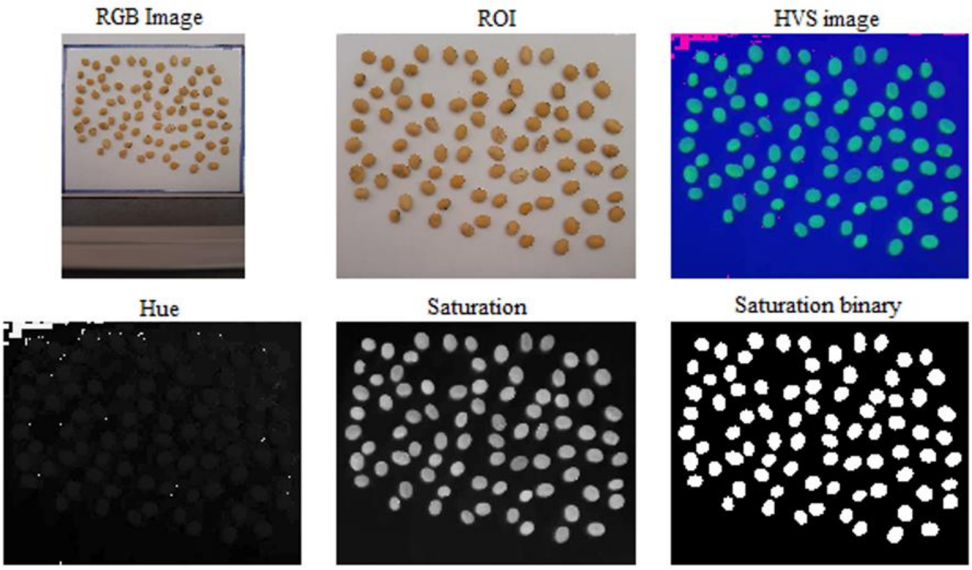

Figure 1. Image transformation processes.

Table 1. Total pixel counts and weights belonging to images of soybean groups

Group No	Irrigation method (%)	Number of pixels (Pcs)	Mean	Weight	Mean
1		1773989		10.4566	
2	100	181422	184621	11.8426	11.6711
3		198452		12.7141	
4		190834		10.8710	
5	75	144092	174757	6.6646	9.5187
6		189345		11.0204	
7		175557		9.6025	
8	50	162188	165019	8.8541	8.8513
9		157311		8.0952	
10		183987		11.0756	
11	25	179750	183628	11.5957	11.5026
12		187147		11.8365	

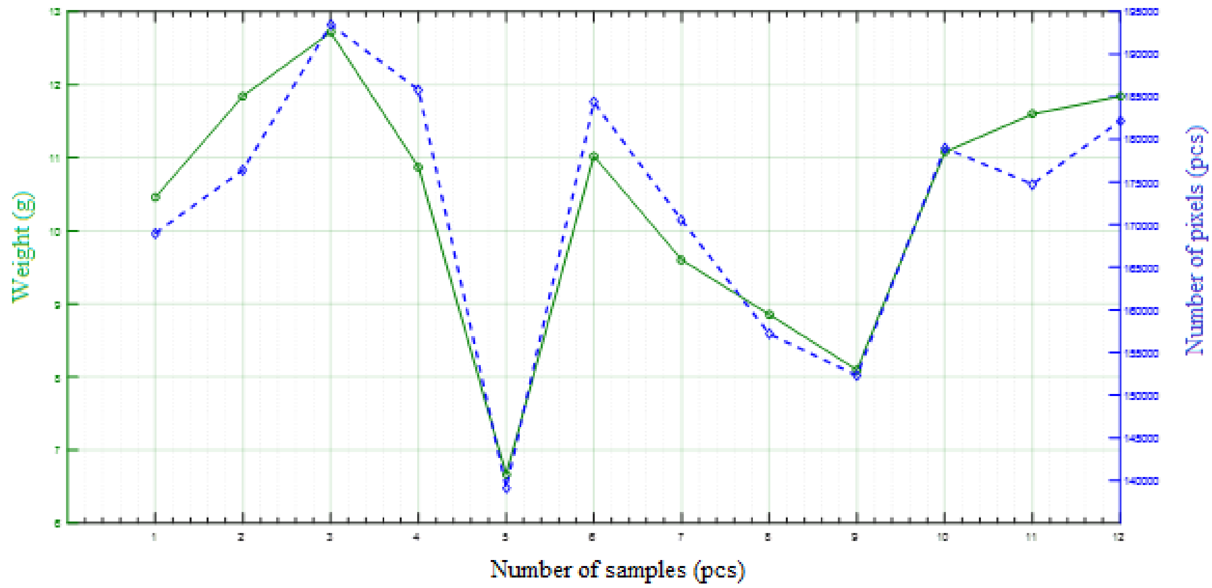

Figure 2. Graph of total pixel counts and weights belonging to images of soybean groups.

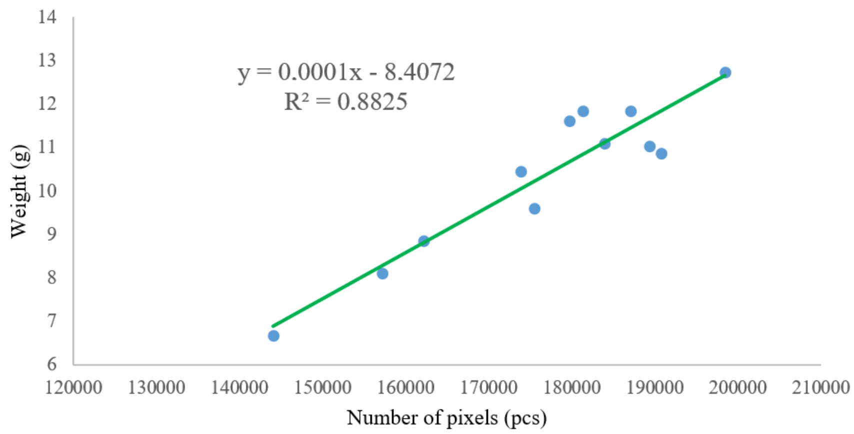

Figure 3. Relationship between total pixel counts and weights belonging to images of soybean deed groups.

4. Discussion

In many studies, image processing techniques have been used to determine product quality by analyzing the shape, size and weight of agricultural products. Sharma et al. (2021) performed an image processing based investigation to classify wheat physical properties such as size, shape, color, and texture. They examined the relationship between the weight and volume of four wheat speices. A linear relationship (R^2 in the range of 0.841–0.920) was found between individual kernel weight and projected area estimated using image processing methodology. Sabanci et al. (2016) were performed weight estimation of bread wheat (Average success rate, 98.29) and durum wheat (Average success rate, 97.54) in diffirent amounts was performed by using image processing techniques. In this study, this value was obtained as 88.25% for soybean. This difference was thought to be due to the fact that the shape and structural properties of soybean, which is an oil seed plant, are different from cereals.

Many studies have shown that when water-stressed, grain crops such as soybeans have decreased in grain weight and yield value as water stress increases (Shaw and Laing, 1966; Huck et al., 1983; Foroud et al., 1993; Lopez et al., 1996a; Lopez et al., 1996b;). In this study, while the results of the experiments up to 25% irrigation were similar, there was a difference in the results of 25% irrigation. This indicates that soybean was subjected to significant stress due to 25% irrigation. Taiz and Zeiger (2008) have mentioned that some plants can manage water efficiently by physiologically storing it in the soil in lands where water stress is severe and can use it for the remaining period of its life for the development of certain regions. It is assumed that 75% water limitation applied to soybean in this study has improved the plant seeds. Therefore, due to excessive stress, the seed weights and sizes have increased and consequently, the total pixel count has also increased in the 25% irrigation condition.

5. Conclusion

In this study, the plant seed weight and pixel size decreased from 100% irrigation rate to 50% irrigation rate and increased at 25% irrigation rate. The increase in plant seed weight and pixel size at 25% irrigation rate is an important indication of the response of plants to stress. In conclusion, the actual weights of soybean seeds for all irrigation rates were determined with 88% accuracy using the total number of pixels occupied on the image. Investigating the effects of moisture content and species differences on weight estimation could lead to more accurate results.

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	H.Ka.	H.Ku.	M.K.G.
C	40	30	30
D	30	40	30
S	40	30	30
DCP	30	30	40
DAI	40	30	30
L	20	50	30
W	60	20	20
CR	60	20	20
SR	70	30	
PM	30	40	30
FA	40	30	30

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because there was no study on animals or humans.

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