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Research Article

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Determination of Strength Properties for Mechanical Harvest of Purslane (*Portulaca oleracea*)

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Abstract Purslane (*Portulaca oleracea* L.) is a common weed that grows all over the world and is one of the most widespread weed species in summer crops. Although purslane vegetable to produce small areas our country, it has started to make production in large and larger areas in recent years. This study aimed to determine the strength of Purslane (*Portulaca oleracea*) specifications for mechanical harvesting. For this purpose, properties as the maximum force, stress in the maximum force point, work at maximum force point, shearing force, deformation at maximum force, bioyield force, and shearing stress of Purslane (*Portulaca oleracea*) stalk, flower have determined. Average values for maximum force, stress and energy in maximum force were determined as 5.560N, 0.323MPa and 0.022 J at stalk, respectively. The shearing force and shearing stress were found to be as 2.420 N and 0.109MPa, respectively. Average values for bioyield force were determined to be 4.448 N. These features can be used in determining the design and operating conditions for the mechanical harvester cutting blade.

Keywords Purslane (*Portulaca oleracea*), strength properties, mechanical harvesting

Introduction

The botanical name is *Portulaca oleracea* L., belonging to the Portulacaceae family. Seven subspecies belong to this species, but the subspecies oleracea and sativa are the most common. *P. grandiflora* is also widespread as a flower species. The Latin name seems to have two meanings: a) 'little door', deriving from the latin 'portula', because of the way its capsule opens, and b) 'porto' (which means carry) plus 'lac' (which means milk), referring to the succulent consistence of stems and leaves [1,2]. In the Middle Ages the Arabs called it 'baqlahamqa', which means 'mad' or 'crazy vegetable', because its branches spread over the ground without control. Purslane seems to have an Asian origin (Iran, India, Russian southern regions) [3,4] supposed that it was cultivated more than 4,000 years ago. In Ancient Egypt it was already used as a medicinal plant. There is evidence of its cultivation in Arabia and in the Mediterranean Basin since the Middle Ages. The species has a cosmopolitan distribution, but it is more present in the Mediterranean area, mainly in the arid and semi-arid lands of northern Africa and southern Europe. In particular, in Saudi Arabia, the United Arab Emirates, and Yemen, P. oleracea subsp. sativa is largely cultivated and available in many vegetable shops and used as salad. In the USA purslane is considered a minor crop because of its use in ethnic cooking [5]. Wild purslane was sold by street-vendors in southern Italy during the 1950s and 60s. 'Purslane is a summer herbaceous plant, with branched, decumbent or fairly ascending stems' [3]. Cultivated forms are more upright and vigorous than wild forms. Plants are succulent, glabrous, with reddish cylindrical stems, up to 50 cm long, with dicotomic growth. Leaves are opposite, oval and glabrous, fleshy, spoon-shaped, up to 3 cm long. Root is a taproot. Flowers are yellow, small, with 5 petals, frequently solitary at the end of the branches, where secondary stems grow.

Flowering occurs from July to September. Fruits are capsules containing a lot of black seeds. The germinating capacity lasts eight to ten years if the seeds are stored dry at a low temperature [3,6,7]. The weight of 1,000 seeds is about 0.13 g.

Figure 1: Purslane (Portulaca oleracea L.) plant

It has 23 000 (1000 ha) of farmland in Turkey. 3,4 percent of this area (809 000 ha) used for vegetable production. Vegetable production has been increasing in recent years. According to 2018 data; the Purslane production volume is 4 382 tons in Turkey. The vegetable mechanization is mostly conducted by hand in Turkey. Mechanization is needed due to the increase in production area. The studies generally focused on chemical, medicinal and culinary of purslane (*Portulaca oleracea* L.). However, studies on strength properties of purslane (*Portulaca oleracea* L.) are limited. This study covers determination of maximum force, bioyield force, shearing force, stress and energy in maximum force, shearing deformation and shearing stress of purslane (*Portulaca oleracea* L.) stalk, leaf.

Materials and Methods

For this study, purslane (*Portulaca oleracea* L.) plants were harvested by hand from the purslane (*Portulaca oleracea* L.) harvested from a greenhouse in the Isparta province, Turkey.

Diameter and cross-sectional area of the experimental samples were measured before the shearing tests. Moisture content of the plants was determined at harvest time. Specimens were weighed and dried in an oven at 102°C for 24 h and then reweighed [8]. It was provided concise but complete information about the materials and the analytical and statistical procedures used.

A universal testing machine (LF Plus, UK) with a 500 N load cell and a computer-aided cutting and picking apparatus (Fig. 2, Fig. 3) was used to measure the strength properties of the purslane (*Portulaca oleracea* L.) plant. Knife material was hardened iron. All the tests were carried out at a speed 1.0 mm s^{-1}, and data were recorded at 10 Hz. All data were analyzed by nexygen software program.

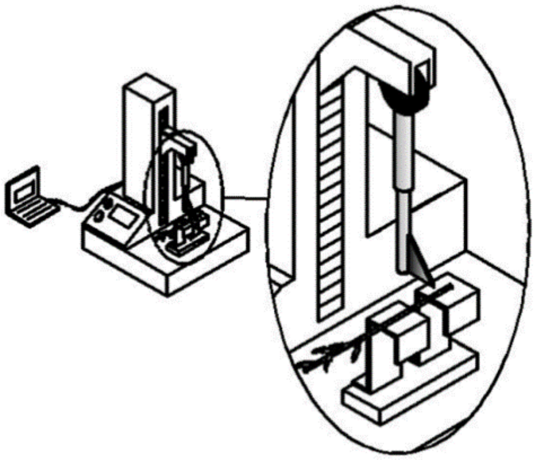


Figure 2: Cutting system

The shearing forces on the load cell with respect to knife penetration were recorded by computer.

The shearing stress in N/mm^2 was calculated using the equation of [9]:

$$\tau = \frac{F_{s\max}}{A} \quad (1)$$

Where Fsmax is the maximum shearing force of the curve in N, and A is the area of the stalk at the deformation cross-section in mm^2.

The purslane (*Portulaca oleracea* L.) plants were attached to the apparatus from its stalks (Fig. 3). The shearing tests were conducted with 0.8 mms^{-1} knife speed progress [10].

Figure 3: Measuring the cutting of purslane (Portulaca oleracea L.) plant

Leaf force can be defined as the force required to separate leaf stalks from ovary point (picking force of leaves). The load cell of the machine was then pulled upward to determine the leaf force of the purslane (*Portulaca oleracea* L.) leaf (Figure 4).

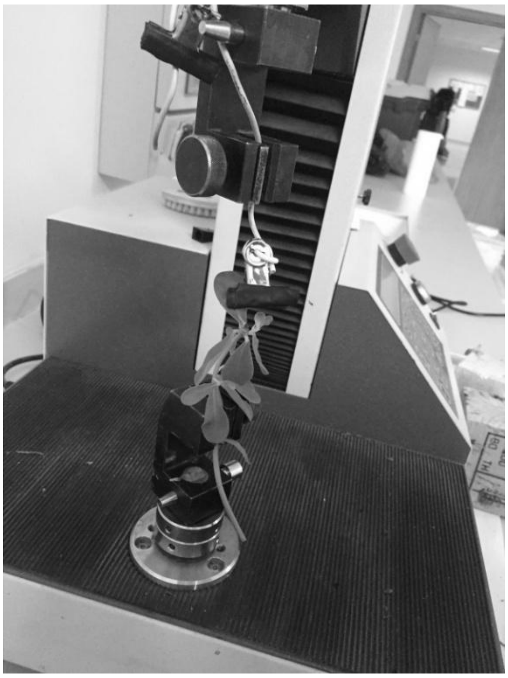
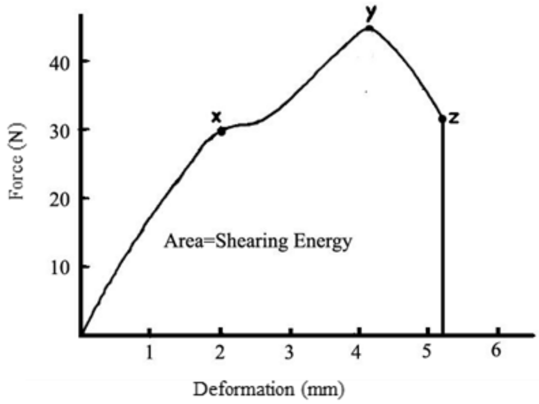


Figure 4: Measuring the leaf force of purslane (Portulaca oleracea L.) leafstalk

Maximum force, bioyield force, shearing force, stress and energy in maximum force, shearing stress and shearing deformation were calculated from the force-deformation curves at the inflection point as defined by ASAE Standard (1985). S368.1 [11] was obtained from all curves (Figure 5).
The energy of shearing was determined as the area under these curves [12,13].



Note. Labels on the graph indicate the following points:
x – bioyield force, y – maximum force, z – shearing force [14]

Figure 5: Typical force-deformation curve of purslane (Portulaca oleracea L.) stalk during shearing loading

Results and Discussions

Moisture content of the purslane (*Portulaca oleracea* L.) was determined as 87.4% at harvest time and all tests were conducted at harvest moisture. The strength measurements of purslane (*Portulaca oleracea* L.) stalks are given in Table 1.The maximum force was observed as 5.560 N at purslane (*Portulaca oleracea* L.) stalk. The bioyield force of 4.448 N was observed at stalk.

Table 1: Average strength properties of purslane (*Portulaca oleracea* L.) stalk

	Maximum force (N)	**Bioyield force (N)**	**Shearing force (N)**	**Stress in maximum force (MPa)**	**Energy in maximum force (J)**	**Shearing stress (MPa)**	**Shearing deformation (mm)**	**Area (mm^2)**
Stalk	5.560	4.448	2.420	0.323	0.022	0.109	33.036	17.511
Standard Deviation	2.371	1.897	1.165	0.076	0.012	0.129	2.767	3.281

Shearing force is one of the most important plant characteristics affecting plant harvesting. If the weight of the plant is known, the shearing force and the shearing height can be used to determine the speed of the blade to be used in harvesting [15, 16]. The maximum shearing force was observed as 2.240 N at stalk. The stress value in maximum force as 0.323MPa was observed at stalk.

The energy at maximum force was found to be as 0.022 J. Deformation has an important place among the strength characteristics of the plant. The maximum shearing deformation (33.036 mm) was observed at stalk. The average cross-sectional area of purslane (*Portulaca oleracea* L.) was determined as 17.511 mm^2 at harvest moisture (87.4 %). The strength measurements of purslane (*Portulaca oleracea* L.) leaf are given in Table 2.

Table 2: Average strength properties of purslane (*Portulaca oleracea* L.) leaf

	Maximum force (N)	**Bioyield force (N)**	**Shearing force (N)**	**Stress in maximum force (MPa)**	**Energy in maximum force (J)**	**Shearing stress (MPa)**	**Shearing deformation (mm)**
Flower(Leaf)	1.507	1.205	0.935	0.184	0.009	0.09	11.917
Standard Deviation	0.698	0.558	0.527	0.058	0.002	0.02.	4.541

The maximum force required to separate leaf from stalk was determined as 1.507 N. As a function of the maximum force the bioyield force was found to be 1.205 N. Lower shearing forces required for mechanical harvesting leads to savings in power and energy usage. Leaf shearing force of purslane (*Portulaca oleracea* L.)

observed 0.935 N is lower than stalk shearing force. The maximum stress in maximum force value (0.184MPa) was observed at leaf. The energy at maximum force was found to be as 0.009 J. The stress shearing value was observed as 0.09MPa. The average shearing deformation value of purslane (*Portulaca oleracea* L.) leaf was found as 11.917 mm.

Conclusions

This study was carried out to determine the strength properties of purslane (*Portulaca oleracea* L.) at leaf and stalk sections in the harvest moisture. Properties as the maximum force, bioyield force, shearing force, stress in maximum force, energy in maximum force, shearing stress, shearing deformation of purslane (*Portulaca oleracea* L.) leaf and stalk have determined at moisture content of %87.4.The strength parameters measured at root section higher than that of the stalk and leaf sections. The lowest values were found at purslane (*Portulaca oleracea* L.) stalk. The strength parameters of stalk section should be considered for mechanical harvesting of rocket plant to provide data for the design machines for mechanized applications.

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