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Research Article

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Determination of Threshing Performance of New Design Threshing Unit for *Origanum onites*

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Abstract In this study, the threshing system performances required for *Origanum onites* have been determined. Physico-mechanical properties used in the design of the threshing system were determined in three different moisture range for *Origanum onites* plant and the system design has been made according to the harvest moisture values.

In this study, threshing efficiency, work efficiency, power requirement and specific energy consumption values of the threshing unit developed were determined. In order to determine the threshing performance of the prototype, experiments were made at 3 different moisture ranges, 3 different drum speed, 3 different drum-concave open and 3 different feeding rates. Each experiment was performed in 3 replicates. As a result, a total of 243 experiments were carried out for a plant in the threshing experiments.

According to the study results, threshing efficiency for *Origanum onites* in the study has been changed between 49.53% and 89.90%. Work efficiency of threshing units has been changed between 2.17 kgh^{-1} to 15.65 kgh^{-1}. Power requirements and specific energy consumption of threshing units have been determined as between 0.397 kW to 0.930 kW and 0.03 to 0.27 $kWhkg^{-1}$ respectively.

Keywords *Origanum onites* , threshing, design, aromatic plant

Introduction

Thyme (family Lamiaceae [Labiatae]; genera Origanum, Satureja, Thymbra, Thymus), is a valuable essential oil and spice crop. Many varieties of thyme are used and marketed worldwide, including garden thyme (*Thymus vulgaris* L.), lemon thyme (*Thymus x citriodorus*), Syrian oregano (*Origanum syriacum* L.), Turkish oregano (*Origanum onites* and *O. minutiflorum*), and sweet thyme (*Origanum marjorana*). Various species of Origanum, Thymus, Satureja, and Thymbra are used in Turkey. The distribution of thyme species in Turkey among genera is as follows: Thymus, 38 species (52% endemic); Origanum, 23 species (65% endemic); and Satureja, 14 species (28% endemic). In Turkey, Origanum species are the most collected among thyme plants. Species of particular commercial importance in the Aegean, Mediterranean, and Southeast Anatolia regions include (*Origanum onites*) (Figure 1), Istanbul thyme (*O. vulgare* ssp. hirtum), *O. minutiflorum*, *O. marjorana*, and *O. syriacum* [1].

Numerous studies have carried out on sage plants, but work on the mechanization of the *Origanum onites* plant is limited. Harvesting, threshing and cleaning medical aromatic plants is very important. The *Origanum onites* plants have been wildly collected and processed from the nature. In recent years, however, studies carried out on cultivating some species have provided higher productivity and quality production. During the processing of these plants such as threshing of the products some problems are emerged and lead to the yield loss and damages on products. In order to overcome this problem, it is necessary to know the operating conditions and performance values of the machines designed according to the plant. In the course of determining of threshing unit performance threshing efficiency, seed damage, unbroken capsule percentage, specific energy consumption, power requirement are used [2].

In this study, the threshing parameters and the system performance such as threshing efficiency, work efficiency, power requirement and specific energy consumption of a threshing unit designed and developed for *Origanum onites* have been determined

Figure 1: Origanum onites plant

Materials and Methods

The specific threshing unit designed for *Origanum onites* plant has been used during the performance experiments. The threshing unit consists of 2 rasp bar type threshing cylinders, 2 gear motors, torque meter for power measurement, cylinders distance mechanism (Fig. 2). The system also has product observation window on the main frame. For this study, the *Origanum onites* plants were harvested by hand from the experimental field in The University of Isparta Applied Science, Turkey [3-5]. In order to calculate the torque and the power consumed by the threshing unit a torque meter connected between the reducer electric motor and the drum shaft.

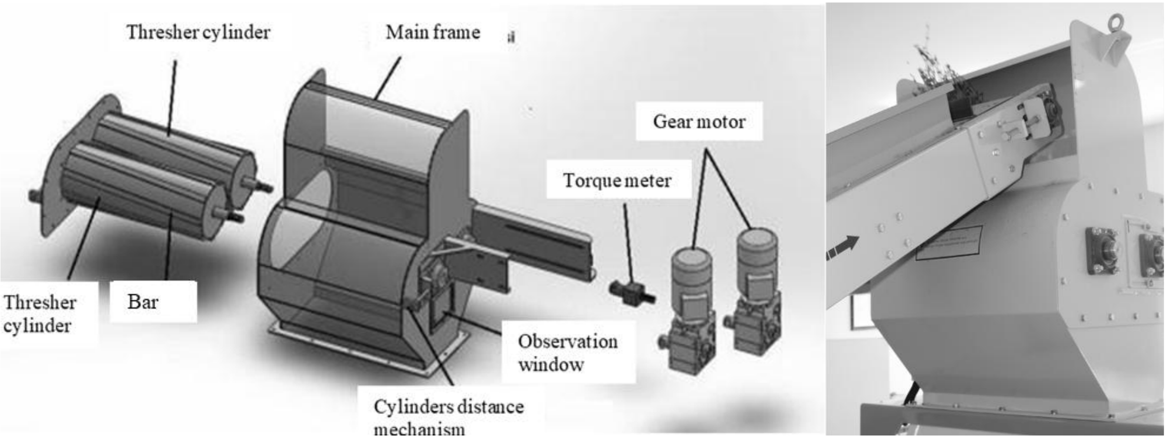
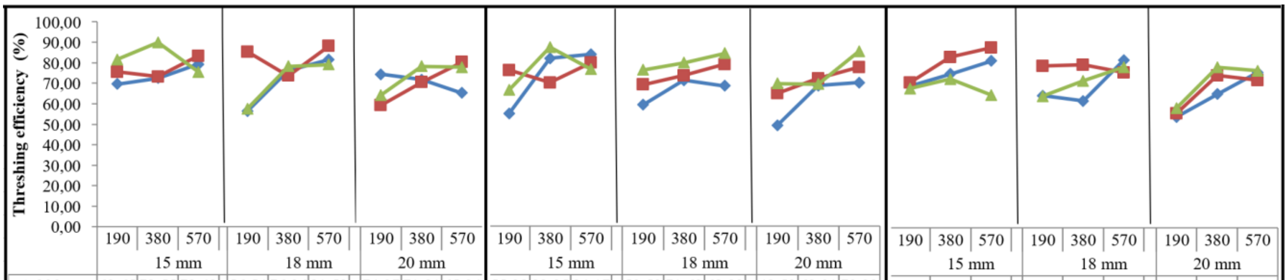


Figure 2: The threshing unit used in the experiments

The *Origanum onites* plants have been dried in the rooms at 35 ° C after harvesting. In order to determine the threshing performance of system the experiments have been conducted at 3 different moisture contents as 8.4%, 10.2% and 13.3% d.b. The threshing cylinders (drum) speeds of the unit have been determined as 200, 300 and 400 rpm. 3 different drum-concave open for the threshing unit have been adjusted as 15, 18 and 20 mm. The product feeding rates have been determined as 190, 380, 570 kgh^{-1}. Conveyor belt speed of feeding unit is determined as 0.26 m/s. Each experiment has been performed in 3 replicates.

Results and Discussions

Because of the experiments conducted depending on the moisture content of the *Origanum onites* , drum-concave opening, feeding rate and drum speed of the threshing system, the threshing efficiency values have been range from 49.53% to 89.90%. The threshing unit efficiency for *Origanum onites* depending on the 3 different moisture contents are given in Fig. 3.

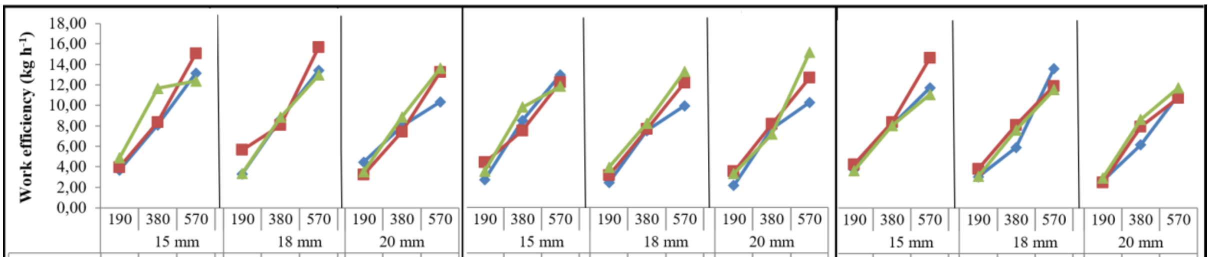


	8.4% moisture content (d.b.)									10.2 % moisture content (d.b.)									13.3 % moisture content (d.b.)								
	15 mm			18 mm			20 mm			15 mm			18 mm			20 mm			15 mm			18 mm			20 mm		
	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570
200 rpm	69,65	72,55	79,42	56,54	76,36	81,53	74,37	71,81	65,34	55,28	82,35	84,17	59,53	71,62	68,82	49,53	69,01	70,32	69,23	75,14	81,51	64,66	62,01	82,05	54,10	65,36	75,90
300 rpm	75,59	73,19	83,42	85,38	73,69	88,17	59,35	70,50	80,39	76,51	70,37	80,15	69,39	73,82	79,36	65,17	72,37	77,94	71,04	83,40	87,89	78,99	79,60	75,97	55,98	74,52	72,15
400 rpm	81,70	89,90	75,49	57,69	78,33	79,16	64,23	78,30	77,85	66,80	87,78	76,87	76,66	80,12	84,77	69,96	69,65	85,85	68,00	72,72	64,93	64,26	71,81	78,42	58,53	78,48	76,81

Figure 3: The effect of drum-concave opening × feeding rate× drum speed on the threshing efficiency at different moisture contents

As a result of the threshing experiments depending on the moisture content of the *Origanum onites*, the threshing efficiency have been decreased as the moisture content have been increased. The triple interaction of drum-concave opening × feeding rate× drum speed on the threshing efficiency at 8.4%, 10.2 and 13.3% d.b. moisture contents has have been found statistically significant ($p<0.05$). The highest threshing efficiency value has been found at 8.4% d.b. moisture content, 15 mm drum-concave opening, 400 rpm drum speed and 380 kgh^{-1}feeding rate. On the other hand, the lowest efficiency value has been found as. 49.53% at the 10.2% moisture content, 20 mm drum-concave opening, 200 rpm drum speed and 190 kgh^{-1}feed rate.

According the result of the study conducted depending on the moisture content of the *Origanum onites* , drum-concave opening, feeding rate and drum speed of the threshing system, the work efficiency values of the system was given in Fig. 4.



	8.4% moisture content (d.b.)									10.2 % moisture content (d.b.)									13.3 % moisture content (d.b.)								
	15 mm			18 mm			20 mm			15 mm			18 mm			20 mm			15 mm			18 mm			20 mm		
	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570
200 rpm	3,69	8,08	13,13	3,30	8,62	13,42	4,45	7,96	10,32	2,71	8,47	12,90	2,42	7,47	9,90	2,17	7,67	10,22	3,77	8,08	11,73	3,05	5,91	13,60	2,63	6,18	11,01
300 rpm	3,96	8,37	15,07	5,64	8,05	15,65	3,23	7,41	13,25	4,38	7,47	12,20	3,15	7,62	12,13	3,50	8,10	12,64	4,27	8,38	14,60	3,82	8,09	11,88	2,52	7,95	10,74
400 rpm	4,87	11,64	12,37	3,36	8,83	12,96	3,50	8,85	13,64	3,55	9,74	11,78	3,93	8,18	13,23	3,33	7,11	15,08	3,65	8,06	11,08	3,09	7,61	11,52	2,96	8,63	11,71

Figure 4: The effect of drum-concave opening × feeding rate × drum speed on the work efficiency at different moisture content

According to the result of the study depending on the moisture content of the *Origanum onites* plant, the work efficiency has increased with increasing moisture content. The triple interaction of drum-concave opening × feeding rate× drum speed on the work efficiency at 8.4%, 10.2% and 13.3% d.b. moisture contents has been found statistically significant ($p<0.05$). The work efficiency values changed between 2.17 kgh^{-1} to 15.65 kgh^{-1}.

The highest work efficiency value has been found at 8.4% d.b. moisture content, 18 mm drum-concave opening, 300 rpm drum speed and 570 kgh^{-1}feeding rate. On the other hand, the lowest work efficiency value has been found at the 10.2% moisture content, 20 mm drum-concave opening, 200 rpm drum speed and 190 kgh^{-1}feed rate

Power requirement of the threshing unit should be known for system performance. The power requirement values of the threshing units carried out at 3 different moisture contents are presented in Figure 5.

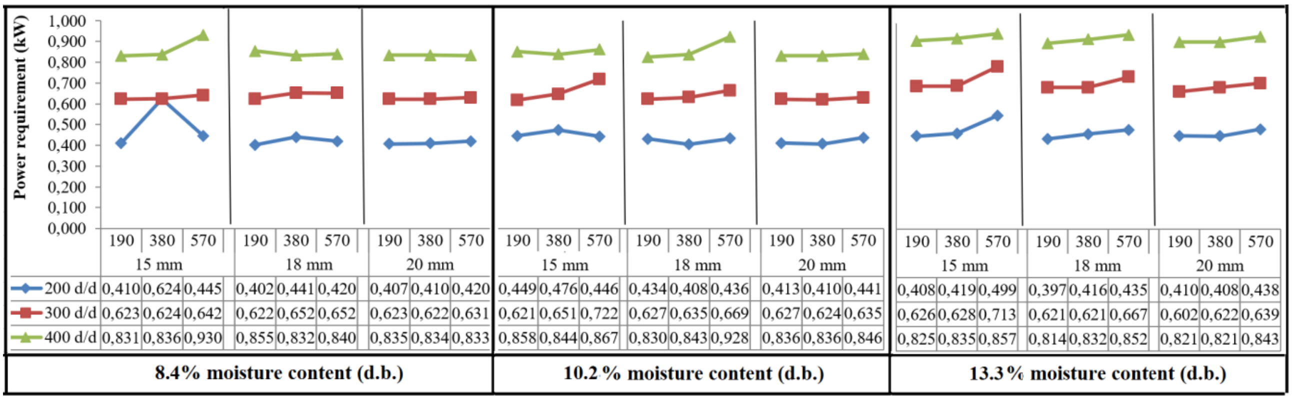


Figure 5: The effect of drum-concave opening × feeding rate × drum speed on the power requirement at different moisture contents

The power requirement values of the system according to the measured values depending on the moisture content of the *Origanum onites*, drum- concave opening, feeding rate and drum speed of the threshing unit, varied between 0.397 kW to 0.930 kW. The triple interaction of drum-concave opening×feedingrate×drum speed on the power requirement at 8.4% 10.2% and 13.3% d.b. moisture contents have been found statistically significant ($p<0.05$). While the lowest power requirement of the threshing unit for *Origanum onites* found at 13.3 % moisture content, 18 mm drum-concave opening, 200 rpm drum speed, 190 kg h^{-1} feeding rate. The highest values have been obtained at 8.4 % moisture content, 18 mm drum-concave opening, 400 rpm drum speed, 570 kg h^{-1} feeding rate.

Specific energy consumption of machine must be known for the proper system performance of threshing unit. The specific energy consumption values of the threshing unit carried out at 3 different moisture contents were varied from 0.03 to 0.27 $kWhkg^{-1}$ and presented in Figure 6.

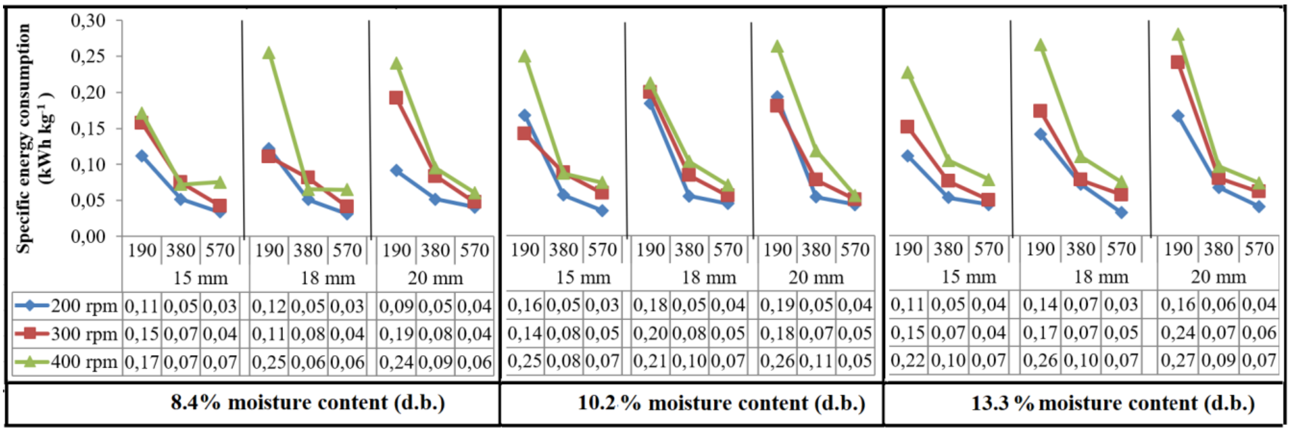


Figure 6: The effect of drum-concave opening × feeding rate × drum speed on the specific energy consumption at different moisture contents

The triple interaction of drum-concave opening × feeding rate× drum speed on the specific energy consumption at 8.4%, 10.2% and 13.3% d.b. moisture contents have been found statistically significant ($p<0.05$). While specific energy consumption of threshing unit for *Origanum onites* has been highest at 13.3% moisture content, 20 mm drum-concave opening, 190 kgh^{-1}feeding rate and 400 rpm drum speed.

Conclusions

In this study, threshing unit performance values and working parameters have been determined for the *Origanum onites*. The threshing efficiency, work efficiency and specific energy consumption values of new design threshing unit have been determined.

When the new design threshing unit for *Origanum onites* is examined in terms of threshing efficiency, it is recommended to operate the threshing unit with 8.4% d.b. moisture content at 15 mm drum-concave opening, 380 kgh^{-1} feeding rate and 400 rpm. On the other hand, it is suggested that for the high work efficiency, threshing unit can be performed with 8.43% d.b. moisture content, 18 mm drum-concave opening, 570 kgh^{-1} feeding rate and 300 rpm drum speed for the l*Origanum onites*. The working parameters should be selected as 13.3% moisture content, 18mm drum-concave opening, 190 kgh^{-1} feeding rate and 200 rpm drum speed for the minimum power requirement. According to the results, it can be said that the most suitable working parameters for the threshing of *Origanum onites* plants are 8.4% of moisture content, 15 mm of drum-concave opening, and drum speed values is recommended as 100 or 400 rpm.

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