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THE EFFECT OF THE DIAMETER OF THE PILING ROLLER OF THE POMEGRANATE BURYING MACHINE ON ITS PERFORMANCE INDICATORS

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Abstract

This article presents the results of research on the operational parameters of a pomegranate burying machine, focusing on the effect of the piling roller's diameter on its performance indicators. Experiments were conducted by varying the small and large diameters of the piling rollers across different intervals under operating speeds of 5 km/h and 7 km/h. The study analyzed the cutting, breaking, and tearing rates of the pomegranate bush trunk part, as well as the damage rate of pomegranate branches. The results demonstrated that increasing the large diameter of the rollers from 30 mm to 70 mm significantly reduced the damage rates, while further increases had a negligible effect. The optimal small and large diameters of the rollers were determined to be 55 mm and 70 mm, respectively, ensuring compliance with agrotechnical requirements. The findings provide valuable insights into improving the machine's design to minimize crop damage and enhance efficiency in pomegranate burying operations.

Keywords: Pomegranate burying machine, piling roller, cutting rate, breaking rate, tearing rate, damage rate, agrotechnical requirements.

1. Introduction

This article describes the structure and operation of the machine, which covers the pomegranate bushes, the width of the enclosure and the depth of immersion

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in the soil, the transverse distance between them, the angle of installation of the casing lemeks relative to the wall and their angle of entry into the soil. The results of the research are presented below. In this case, the width of the hulls and the depth of immersion in the soil form a pile of soil at the shape and height required to bury the pomegranate bushes, the transverse distance between the hulls does not re-pour the soil overturned by them. Installation and access angles to the soil were determined from the conditions under which they were able to dig the soil without sliding relative to the side, quality rubbing, and low energy consumption. Calculations on the obtained analytical expressions cover the width of the burial bodies at least 45 cm, the depth of immersion not more than 36 cm, the transverse distance between them not less than 1.26 m, showed that the angle should not be less than 60° and the angle of entry into the soil should be in the range of 20-26°[1, 2, 3, 4, 5, 6, 7, 8].

2. Materials and methods. Experiments were conducted by varying the small diameter of the piling roller of the pomegranate burying machine from 25 mm to 70 mm with a 15 mm interval, and the large diameter from 30 mm to 90 mm with a 20 mm interval. In this case, the stiffness of the piling pressure spring was set at 300 N/m, the number of piling rollers was 4, and the operating speed of the unit was set at 5 and 7 km/h. The main indicators were determined as the cutting, breaking, and tearing rates of the pomegranate bush trunk part, as well as the damage rate of the pomegranate branches.

3. Results and discussion. The experimental results are presented in Table 1 and Figures 1–4.

From the results of the experiments presented in Table 1 and Figure 1, the following can be highlighted. As the large diameter of the piling rollers of the pomegranate burying machine increased, the damage rates of the pomegranate bush trunk part and branches decreased. That is, as the large diameter of the rollers increased from 30 mm to 70 mm, and accordingly their small diameter increased from 25 mm to 55 mm, the cutting rate of the pomegranate bush trunk part significantly decreased, ranging from 5.4% to 2.5% at an operating speed of 5 km/h, and from 6.0% to 2.9% at an operating speed of 7 km/h. When the large

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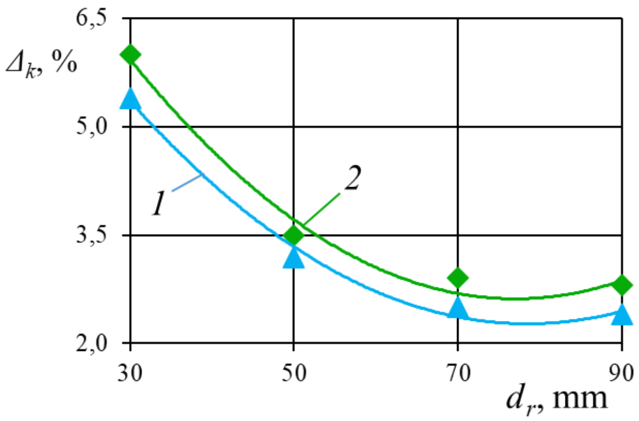
diameter increased from 70 mm to 90 mm and the small diameter remained between 25 mm and 55 mm, the cutting rate of the pomegranate bush trunk part remained almost unchanged. This can be explained by the fact that as the rollers' diameter increases, the contact surface area affecting the pomegranate bushes also increases [9].

Table 1 The effect of the piling roller diameter on its performance indicators

Diameter of the piling rollers, mm		Damage to the trunk part, %			Damage to pomegranate branches, %
Small diameter	Large diameter	cut, %	crushed, broken, %	torn,%	
V=5 km/h					
25	30	5,40	1,70	1,20	6,90
40	50	3,20	0,60	0,40	3,20
55	70	2,50	0,40	0,30	2,90
70	90	2,40	0,50	0,20	2,70
V=7 km/h					
25	30	6,00	2,30	1,40	8,50
40	50	3,50	0,90	0,60	4,30
55	70	2,90	0,80	0,50	3,80
70	90	2,80	0,70	0,40	3,60



1 – at an operating speed of the unit of 5 km/h

1 – at an operating speed of the unit of 7 km/h

Figure 1. The effect of the piling roller's large diameter (d_r) on the cutting rate (Δ_k) of the pomegranate bush trunk part

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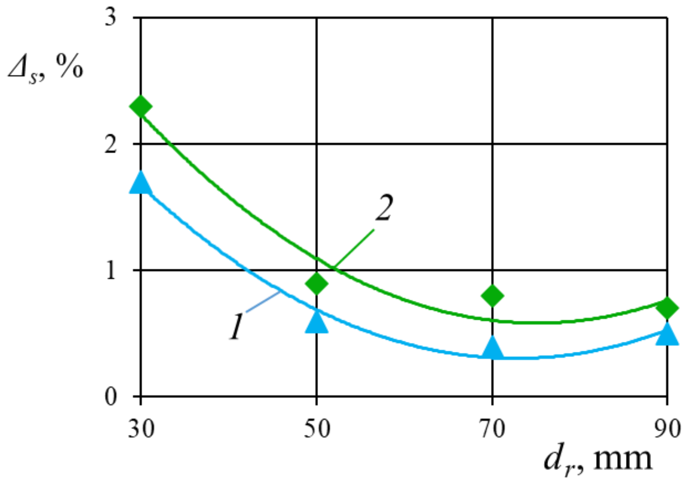

1 – at an operating speed of the unit of 5 km/h
1 – at an operating speed of the unit of 7 km/h

Figure 2. The effect of the piling roller's large diameter (d_r) on the breaking rate (Δ_s) of the pomegranate bush trunk part

When the large diameter of the piling rollers was increased from 30 mm to 70 mm (Figure 2), the breaking rate of the pomegranate bush trunk part significantly decreased, ranging from 1.7% to 0.4% at an operating speed of 5 km/h, and from 2.3% to 0.8% at an operating speed of 7 km/h. When the large diameter of the piling rollers increased from 70 mm to 90 mm, the breaking rate of the pomegranate bush trunk part remained almost unchanged [10].
As seen from the obtained results (Figure 3), when the large diameter of the piling rollers increased from 30 mm to 70 mm, the tearing rate of the pomegranate bush trunk part decreased according to a concave parabolic law, ranging from 1.2% to 0.3% at an operating speed of 5 km/h, and from 1.4% to 0.5% at an operating speed of 7 km/h. As the operating speed of the unit increased from 5 km/h to 7 km/h, the tearing rate of the pomegranate bush trunk part increased. This can be explained by the increase in impact force [11].

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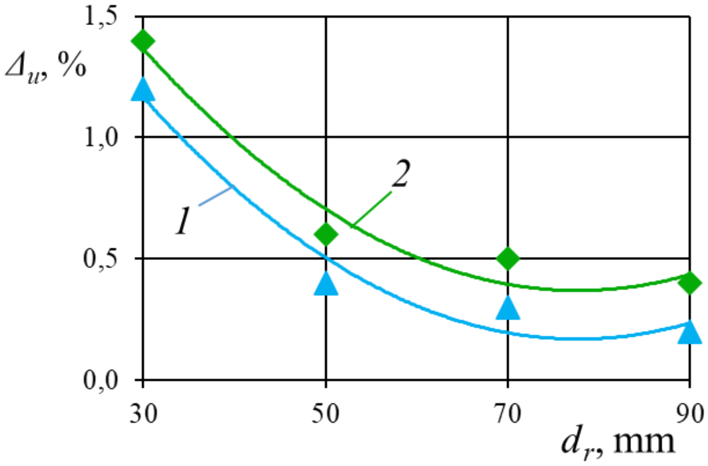
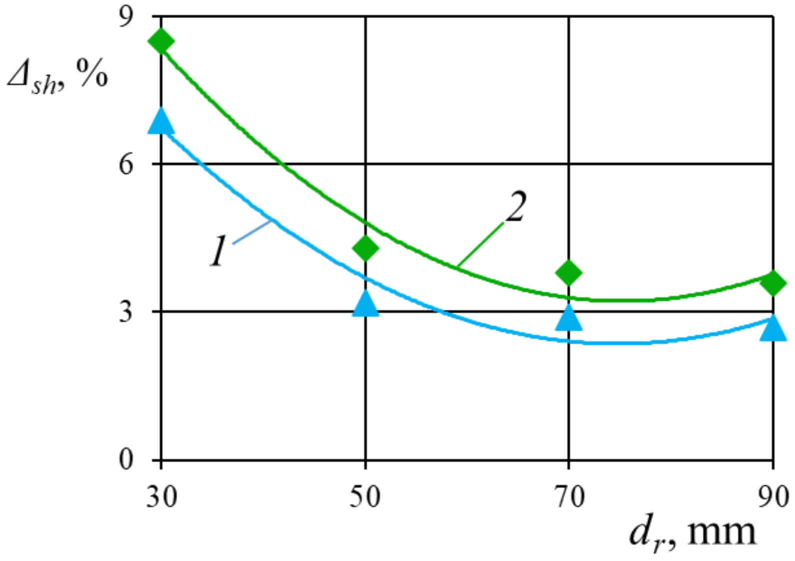


1 – at an operating speed of the unit of 5 km/h
1 – at an operating speed of the unit of 7 km/h

Figure 3. The effect of the piling roller's large diameter (d_r) on the tearing rate (Δ_u) of the pomegranate bush trunk part



1 – at an operating speed of the unit of 5 km/h
1 – at an operating speed of the unit of 7 km/h

Figure 4. The effect of the piling roller's large diameter (dr) on the damage rate (Δsh) of pomegranate branches

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The results of the effect of the piling rollers' large diameter on the damage rate of pomegranate branches are presented in Figure 4. It shows that when the studied diameter increased from 30 mm to 70 mm [12], the damage rate of pomegranate branches significantly decreased at both operating speeds, ranging from 6.9% to 0.3% at 5 km/h, and from 8.5% to 3.8% at 7 km/h. When the large diameter of the rollers increased from 70 mm to 90 mm, the damage rate of the branches changed slightly [13], ranging from 2.9% to 2.7% at 5 km/h, and from 3.8% to 3.6% at 7 km/h [14].This can be explained by the improvement in the centralization of pomegranate branches as the diameter of the rollers increases.

The graphical relationships presented in Figures 1–4 can be expressed using the following empirical formulas obtained by the method mentioned above [15]:

a) For the unit's operating speed of 5 km/h

$\Delta_k = 10{,}354 - 0{,}206\, d_r + 0{,}0013\, d_r^2$ ($R^2 = 0{,}9931$), %; (1)

$\Delta_s = 4{,}265 - 0{,}109\, d_r + 0{,}0007\, d_r^2$ ($R^2 = 0{,}9836$), %; (2)

$\Delta_u = 2{,}8113 - 0{,}068\, d_r + 0{,}0004\, d_r^2$ ($R^2 = 0{,}961$), %; (3)

$\Delta_{sh} = 14{,}576 - 0{,}327\, d_r + 0{,}0022\, d_r^2$ ($R^2 = 0{,}9543$), %; (4)

b) For the unit's operating speed of 7 km/h

$\Delta_k = 11{,}51 - 0{,}231\, d_r + 0{,}0015\, d_r^2$ ($R^2 = 0{,}9855$), %; (5)

$\Delta_s = 5{,}1638 - 0{,}122\, d_r + 0{,}0008\, d_r^2$ ($R^2 = 0{,}9505$), %; (6)

$\Delta_u = 3{,}0113 - 0{,}068\, d_r + 0{,}0004\, d_r^2$ ($R^2 = 0{,}961$), %; (7)

$\Delta_{sh} = 17{,}36 - 0{,}376\, d_r + 0{,}0025\, d_r^2$ ($R^2 = 0{,}9642$), %; (8)

Where Δ_k – Cutting rate of the pomegranate bush trunk part, %;

Δ_s – Breaking rate of the pomegranate bush trunk part, %;

Δ_u – Tearing rate of the pomegranate bush trunk part, %;

Δ_{sh} – Damage rate of pomegranate branches, %;

d_r – Large diameter of the piling rollers (dr = 30–90 mm).

4. Conclusion

The above analysis shows that in order to ensure the damage rates of the pomegranate trunk and branches meet agrotechnical requirements, the small and large diameters of the piling roller should be 55 mm and 70 mm, respectively. It can also be noted that the curved surface of the piling rollers, for example, in the

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form of a hyperboloid, ensures the centralization of pomegranate bushes and branches towards the middle of the piling mechanism.

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