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THE EFFECT OF THE OPENING ANGLE OF FURROW OPENER WINGS WITH UNEQUAL WING ASSEMBLIES ON ITS PERFORMANCE INDICATORS

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Abstract:
This article presents experimental methods for determining the opening angles of a furrow opener with unequal wing assemblies, which is part of a combined machine designed to apply organic fertilizers uniformly in orchards while simultaneously opening irrigation furrows.

Keywords: Moldboard plow, disc plow, opening angle, draft resistance, furrow depth, wing assemblies, machine, soil ridge height.

Introduction

In orchards around the world, especially in pomegranate plantations, scientific research is being conducted to develop new scientific and technical foundations

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for combined machines that apply organic fertilizers—rather than chemical ones—for producing environmentally clean fruit, while simultaneously forming irrigation furrows and partially eliminating weeds between rows, in accordance with resource-saving technologies.

In this direction, particular importance is being given to studies that justify the technological working processes of the working bodies of a combined machine, which applies a specified amount of organic fertilizer to the root zone of pomegranate trees, covers it, and forms irrigation furrows—all in a single pass. These studies also aim to reduce energy consumption during the interaction between the working bodies and the soil.

Therefore, it is considered necessary to develop a resource-efficient machine that can, in one pass, apply organic fertilizer between pomegranate rows, bury the fertilizer, and simultaneously open irrigation furrows using combined machinery. Based on these considerations, scientists from the Andijan Institute of Agriculture and Agrotechnologies and the Scientific Research Institute of Agricultural Mechanization have developed a combined machine capable of applying organic fertilizers to designated spots in the required amount and opening irrigation furrows in a single pass [1].

Experimental research was conducted to identify optimal parameters for furrow openers that apply organic fertilizers locally and ensure high-quality performance with minimal energy consumption. These experiments were based on theoretical studies and comparative tests of furrow openers used for fertilizer application and furrow formation [2].

The experimental studies were carried out in two stages on Field No. 6 of the experimental farm of the Scientific Research Institute of Agricultural Mechanization (SRIAM) after performing plowing, chiseling, harrowing, and leveling operations. Initially, single-factor experiments were conducted, followed by multi-factor experiments. The soil in the experimental field is medium-heavy loam, typical of gray soils.

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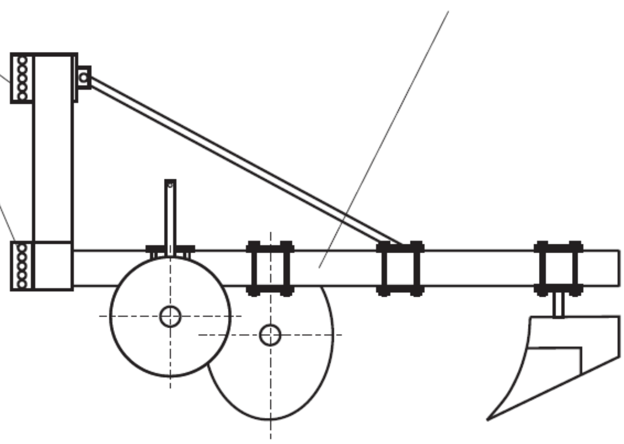

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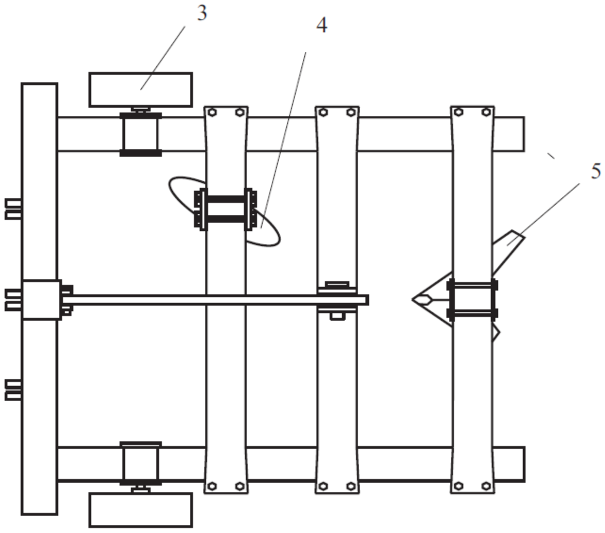

b)

1 – Tractor hitch; 2 – Frame; 3 – Support wheel; 4 – Disc-type furrow opener; 5 – Moldboard-type furrow opener

Figure 1. Structural diagram of the laboratory-field device

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a)

b)

Figure 2. Rear (a) and side (b) views of the laboratory-field device

A special laboratory-field device was prepared for the experiments. It consists of a frame equipped with a suspension mechanism, mounted support wheels, and furrow openers (Figures 1 and 2). The laboratory-field device was designed with adjustable lateral and longitudinal spacing between the furrow openers. Based on the results of comparative tests, disk-type furrow openers for opening furrows for organic fertilizer application and moldboard-type furrow openers for simultaneously covering the fertilizer and forming irrigation furrows were selected for the setup.

The disk-type furrow openers were mounted on the front beam of the frame with a longitudinal spacing of 90 cm. The moldboard-type furrow opener was rigidly

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fixed to the rear beam of the frame using a special lock. For the experiments, the device was aggregated with an MTZ-80 tractor of traction class 1.4.

Before conducting the experiments, the soil moisture, hardness, and density at depths of 0–5, 5–10, 10–15, 15–20, and 20–25 cm were determined based on the research methods outlined in [2], while the composition of soil fractions was identified in accordance with **GOST 20915-2011** “Testing of Agricultural Machinery. Methods for Determining Test Conditions” [3]. The physical and mechanical properties of the experimental field's soil are presented in **Table 1**.

In the first stage of the experiment, the influence of the parameters and operating speed of the furrow opener with unequal wing assemblies on irrigation furrow depth and draft resistance was assessed based on the standards **O’z DSt 3412:2019** “Testing of Agricultural Machinery. Surface Tillage Machines and Implements. Test Program and Methods” [4], and **O’z DSt 3193:2017** “Testing of Agricultural Machinery. Method for Energy Evaluation of Machines” [5; pp. 2–14].

During the experiments, the working body (GX-4) responsible for both covering the organic fertilizer applied by the furrow opener with unequal wing assemblies and simultaneously opening the irrigation furrows was set to a working depth of 25 cm. The opening angle of its wings was adjusted from 60° to 90° in 10° intervals, and additional wings were mounted. These auxiliary wings were varied from 4 cm to 12 cm in 4 cm intervals (Figure 3). Each variant was tested at working speeds of 6 km/h and 8 km/h. During the experiments, when one parameter was

a)

b)

c)

a) 12 cm, b) 8 cm, c) 4 cm

Figure 3. Wings designed for the GX-4 furrow opener to form furrows with unequal wing assemblies

Changed, all other parameters were kept constant.

The profile and dimensions of the irrigation furrows formed by the furrow opener with unequal wing assemblies were measured after the passage of the implement using a 3-meter-long measuring rod marked at every 50 mm and a 500 mm ruler, with measurements taken at 5 cm intervals and an accuracy of ±0.1 cm. To determine the draft resistance of the moldboard-type furrow openers, special strain gauge fingers equipped with bonded strain sensors were used.

The data obtained from the experiments were processed using methods of mathematical statistics, and the arithmetic mean values of the indicators were determined [6; pp. 79–80, 7; p. 36, 8; pp. 179–195, 9; pp. 249–253].

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Table 1 Physical and Mechanical Properties of the Soil in the Experimental Field

S/N	Name of Indicators	Value of Indicators
1	2	3
1.	Soil moisture by layer (cm), **%:** 0-5 5-10 10-15 15-20 20-25	 11,23 13,35 15,47 16,03 17,23
2.	Soil hardness by layer (cm), MPa: 0-5 5-10 10-15 15-20 20-25	 0,42 0,67 0,73 0,84 0,92
3.	Soil density by layer (cm), **g/cm^3:** 0-5 5-10 10-15 15-20 20-25	 1,09 1,13 1,17 1,19 1,23
4.	Quantity of soil fractions by particle size (mm), **%:** <25 25-50 >50	 83,7 12,5 3,8

Figure 4. View of the laboratory-field device during operation

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Experiments were conducted by varying the opening angle of the moldboard-type furrow opener wings from 60° to 90° in 10° intervals. During these tests, the longitudinal installation distance between the moldboard-type furrow opener and the disc-type furrow opener was set at 95 cm and kept constant. The operating speeds during the experiments were set at 6.0 and 8.0 km/h.

The results obtained from the experiments are presented in **Table 2** and **Figure 5**. The experimental data show that as the opening angle of the wings of the furrow opener with unequal wing assemblies increased, the furrow depth initially increased and then decreased at both operating speeds—following a decreasing parabolic trend. When the aggregate operating speed was 6 km/h, increasing the opening angle from 60° to 70° led to a decrease in furrow depth from 15.3 cm to 14.4 cm, and increasing the angle from 80° to 90° resulted in a decrease from 12.6 cm to 10.5 cm. These findings are consistent with the results of the conducted theoretical studies.

Table 2 The Effect of the Opening Angle of Furrow Opener Wings with Unequal Wing Assemblies on Its Performance Indicators

Name of indicators	Opening angles of furrow opener wings with unequal wing assemblies, °							
	60		70		80		90	
	Aggregate speed, km/h							
	6	8	6	8	6	8	6	8
Furrow depth, cm	15,3	14,4	14,2	13,2	12,6	11,5	10,5	9,6
Soil ridge height, cm	9,8	9,1	8,8	8,2	7,3	6,4	5,1	4,3
Draft resistance, N	835	886	917	976	1006	1087	1078	1172

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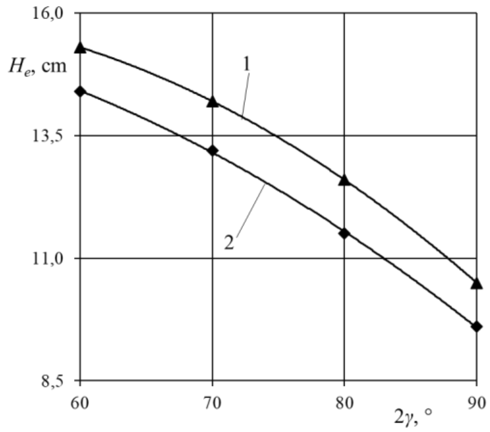

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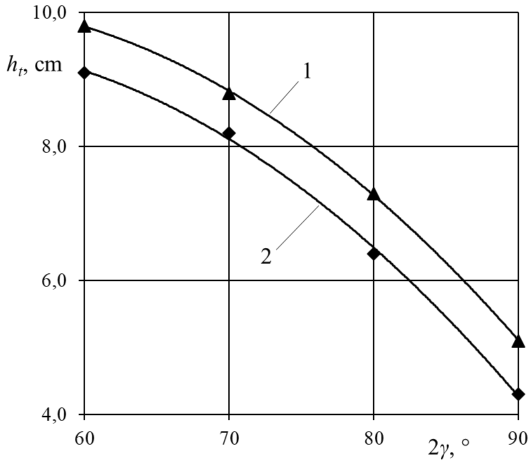

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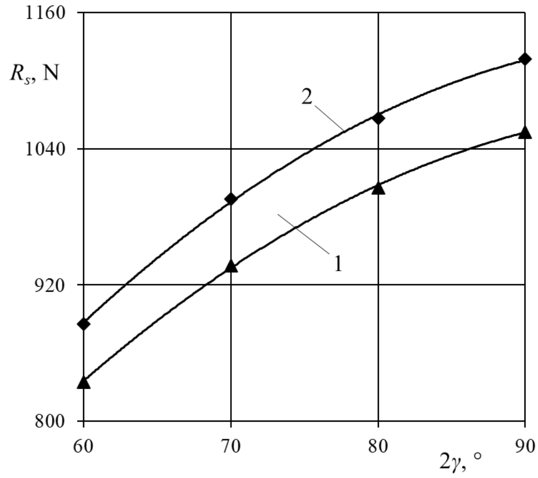

c)

1-6 km/h, 2-8 km/h Aggregate speed

Figure 5. Effect of the opening angle of furrow opener wings with unequal wing assemblies on: a) furrow depth, b) soil ridge height, c) draft resistance

This can be explained by the fact that the opening angle of the furrow opener wings with unequal wing assemblies reaches its maximum effectiveness within the 60–70° range.

At both operating speeds, the height of the soil ridge formed by the furrow opener with unequal wing assemblies decreased. This indicator dropped from 9.8 cm and 9.1 cm to 5.1 cm and 4.3 cm, respectively. As seen in the following graph, the increase in both the opening angle of the wings and the operating speed of the aggregate led to a reduction in soil ridge height. This is attributed to a decrease in the volume of displaced soil.

The draft resistance of the furrow opener with unequal wing assemblies increased as the wing opening angle increased and also rose with the increase in the operating speed of the aggregate. This can be explained by the fact that the surface area of the wings interacting with the soil increased as the opening angle widened.

The opening angle of the wings of a furrow opener with unequal wing assemblies has a significant impact on its agrotechnical and operational performance indicators. Research results show that when the opening angle of the wings is between 70° and 80°, the furrow depth reaches 15.3 cm, the soil ridge height reaches 9.8 cm, and draft resistance is at its minimum. This ensures that the applied organic fertilizer is properly buried according to agrotechnical requirements and that the required irrigation furrows are effectively formed.

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