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Justification of Parameters of a River Field Board

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ABSTRACT. A ripper with differently sized upper and lower working bodies of the “paraplau” type carries out soilless erosion-free tillage. The purpose of the study is to justify the parameters of the field planter ripper. Considered equilibrium ripper in the horizontal plane. Analytical dependences for determining the length and width of the field board are obtained. It has been established that in order to ensure a ripper equilibrium in a horizontal plane, the width and length of its field planks, respectively, should be at least 7 and 16 cm.

KEYWORDS. Ripper, paraplau, field board, stability, horizontal plane, rectilinear motion, unit.

I. INTRODUCTION

Recently, working bodies like "Paraplau" have been widely used not only in America and Europe, but also in Russia. Therefore, scientists from various countries are intensively engaged in the improvement of working bodies such as the Paraplau and the substantiation of its parameters [1, 2, 3, 4].

The authors have developed a ripper with different-sized working bodies such as "Paraplau". When this ripper works, a stepped bottom with large ridges is formed at the bottom of the furrow, which contributes to retention and accumulation of soil water, as a result of which water erosion is prevented [5, 6].

II. SIGNIFICANCE OF THE SYSTEM

The article presents the results of studies to substantiate the parameters of the field planter ripper. The study of literature survey is presented in section III, methodology is explained in section IV, section V covers the experimental results of the study, and section VI discusses the future study and conclusion.

III. LITERATURE SURVEY

In Western Europe and the United States, chisel plows have found fairly widespread as tools for the main tillage. They cultivate the soil to a depth of 30–40 cm, leaving the field surface 60–80% stubble [1, 2]. It has been established that the use of chisel plow instead of plowshare on the main treatment allows reducing energy consumption by 16.5%, and fuel consumption by 16.2% [3]. The Howard Rotovator company (Great Britain) developed the “Paraplau” plow-cultivator for basic soilless tillage, decompression and deepening of the arable horizon. The distinctive structural features of the working bodies of the “Paraplau” plow ripper are the rack inclined at an angle of 45^0 in the transverse-vertical plane and a rotatable adjustable ripper mounted on the rear lower part of the rack [1].

IV. METHODOLOGY

In the studies applied methods of theoretical mechanics and agricultural mechanics. Field boards are the support of the ripper and provide stability of the stroke across the width of the grip and straightness of the movement of the unit in the horizontal plane [7, 8]. The main parameters of the field board are its width and length.

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When considering the equilibrium of the cultivator in the horizontal plane (Fig.1), we assume that the length of all field planters of the cultivator is the same, all field boards are equally loaded, and in the horizontal plane of the projections the equilibrium of the cultivator is provided by the field boards. We assume that the resultant force is applied to the average (or conditionally average with an even number of working bodies) to the working body of the ripper. The same length of field boards allows you to replace the reactive efforts applied to the field board of each working body with the total force applied to the field board of the conventional average working body.

V. EXPERIMENTAL RESULTS

To ensure equilibrium ripper in a horizontal plane, you must comply with the following condition

$$\sum M_A = R_x \cdot OC - N \cdot OD = 0, \tag{1}$$

where R_x – is the resultant forces acting on the working body of the ripper in the horizontal plane; N – is the resultant of the reaction forces applied to the field boards of the working parts of the ripper on the side of the furrow wall.

Of (1)

$$N = R_x \frac{OC}{OD}. \tag{2}$$

From right triangles *OCA* and *ODA*

$$OC = OA \sin\alpha, \tag{3}$$

$$OD = OA \cos(\alpha + \varphi). \tag{4}$$

Substituting the values of *OC* and *OD*, we get

$$N = R_x \frac{\sin\alpha}{\cos(\alpha + \varphi)} \tag{5}$$

where α – is the angle of deviation of the line of plow thrust from the direction of movement of the plow; φ – is the angle of friction of the soil on the field board.

Knowing the magnitude of the force *N*, the specific pressure of the field board on the furrow wall can be determined by the formula

$$p = \frac{N \cos\varphi}{n b_{n\partial} l_{n\partial}} = \frac{R_x \sin\alpha \cos\varphi}{n b_{n\partial} l_{n\partial} \cos(\alpha + \varphi)}, \tag{6}$$

where *n* – is the number of working bodies of the ripper.

From (6) it can be seen that the specific pressure of the field board on the furrow wall depends on the magnitude of the force R_x, the angle of deviation of the ripper thrust line from the direction of movement of the unit, the width and length of the field board, and the angle of soil friction. With an increase in the width and length of the field board, its specific pressure on the furrow wall decreases and vice versa.

It is known that to ensure the work of the plow, including the ripper without boraxing, the specific pressure of its field boards on the furrow wall should not exceed the allowable value of 5 N/cm^2 [8]. With this in mind, from (6), we get

$$b_n l_n \geq \frac{R_x \sin\alpha \cos\varphi}{[p] n \cos(\alpha + \varphi)}, \tag{7}$$

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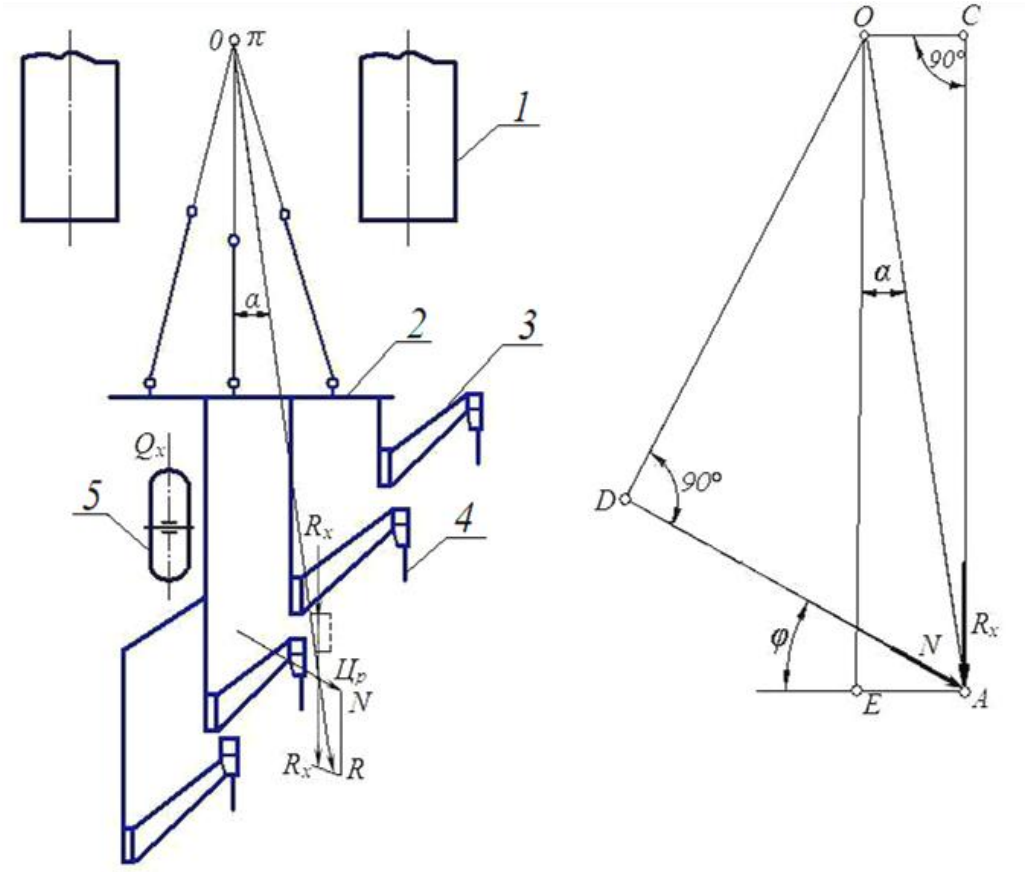

Fig.1. Scheme to determine the width and length of the field planter ripper

where [*p*] – is the allowable specific pressure of the field board on the furrow wall, equal to 0,05 MPa [8].

The width of the field board should be less than or equal to the height of the bit $h_д$, otherwise the soil converging from the bit falls on it, which leads to an increase in the resistance of the ripper. With this in mind

$$b_{nд} \le h_д = 7{,}2 \text{ см}.$$

Accept $b_{nд}$= 7 cm.

From (7) the length of the field board

$$l_{nд} = \frac{R_x \sin\alpha \cos\varphi}{n b_{nд} [p] \cos(\alpha + \varphi)}.$$

Bearing in mind $R = \eta n K a_{cp} b$ expression (7) can be rewritten as follows

$$l_{nä} \ge \frac{\eta K b a_{ñð} \sin\alpha ños\varphi}{[p] b_{ïä}\, ños(\alpha + \varphi)},$$

(8)

where η – is the coefficient of the action of the ripper; K – soil resistivity when loosening; φ – is the angle of friction; a_{sr} – the average depth of processing ripper; b – the width of the working body.

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From the analysis of expressions (7) and (8) it follows that the width and length of the field boards of the two-tier ripper depends on the depth of processing of the upper and lower working bodies, the width of the working bodies, the directions of thrust force and the forces acting on the working bodies, as well as physical mechanical properties of the soil, which depend on the values of [p] and K.

With [p]=5 N/cm^2; K=5 N/cm^2; η =0,7; a_{sr} =35 cm and φ=30^0 [7, 8], showed that to ensure the equilibrium of the cultivator in the horizontal plane, i.e. his work without barreling, the width and length of his field boards, respectively, must be at least 7 and 16 cm.

IV. CONCLUSION

Analytical dependences for determining the length and width of the field board have been obtained. The ripper equilibrium in the horizontal plane has provided with the width and length of its field boards, respectively 7 and 16 cm.

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