Study of Cane Dimensional Characteristics to Justify Sprayer Parameters

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Abstract. Based on the study of dimensional characteristics of reeds, a sprayer is proposed for the treatment of panicles of reeds growing in the elements of the irrigation system of rice checks. The boom of the offered sprayer has an original shape, sprayers of which are located along the trajectory of a parabola, taking into account the placement of the upper points of the panicles across the width of the channel and equipped with a protective chamber device, made in the form of an Archimedes spiral with a spiral pitch equal to at least 20 cm, the offset of the spiral center from the axis of the spraying nozzle vertically is equal to the spiral pitch 20 cm, and from the location of the spraying nozzle to the bottom treatment zone of panicles 40 cm.

Rice growing in Russia has rather short history about 90 years [1]. However for this time thanks to efforts of several generations of rice growers from underdeveloped branch turned to powerful industry, capable to provide completely the country with rice products of own production.

The topical issue is to increase efficiency of check crops protection from cane by reducing pesticide consumption and using new method of local treatment of cane panicles.

The proposed method of rice cultivation provides protection against weed vegetation based on economic thresholds of harmfulness by targeted treatment of weed panicles.

Increasingly, digital technologies are also beginning to be used in rice cultivation, which show an economic effect [2, 3, 4].

The problem is the lack of design and technological scheme and parameters of sprayer for protection of rice cheeks from reeds, providing local treatment of the panicles.

The program of studying the size of different parts of reeds was carried out in Krasnoarmeisky district of Krasnodar region. It included measurements in 10 rice checks (10 measurements of each indicator in a check):

- height of the reed plant near, middle and far edges of the channel from the ground to the highest point of the reed (the upper point of the panicle) and from the ground to the lowest point of the panicle (the lower point of the panicle) – figure 1;
- width of reed spreading;
- number of panicles according to the width of reed spreading in the channel;
- distance between panicles;
- width and length of the panicles.

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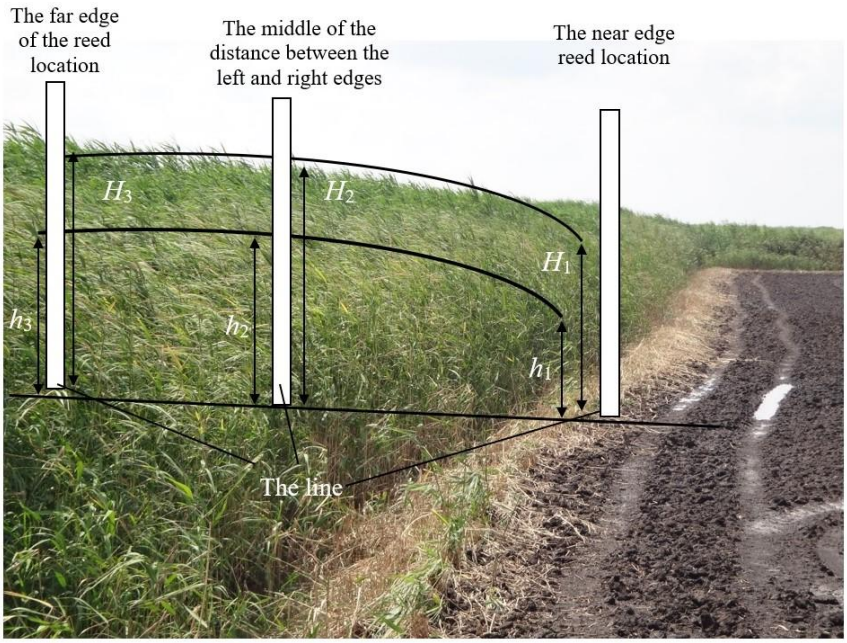


Fig. 1. Scheme for measuring the height of a reed.

The dimensional characteristics of reed panicles were also studied. Both wet (Fig. 2, a) and dry (Fig. 2, b) panicles were cut.

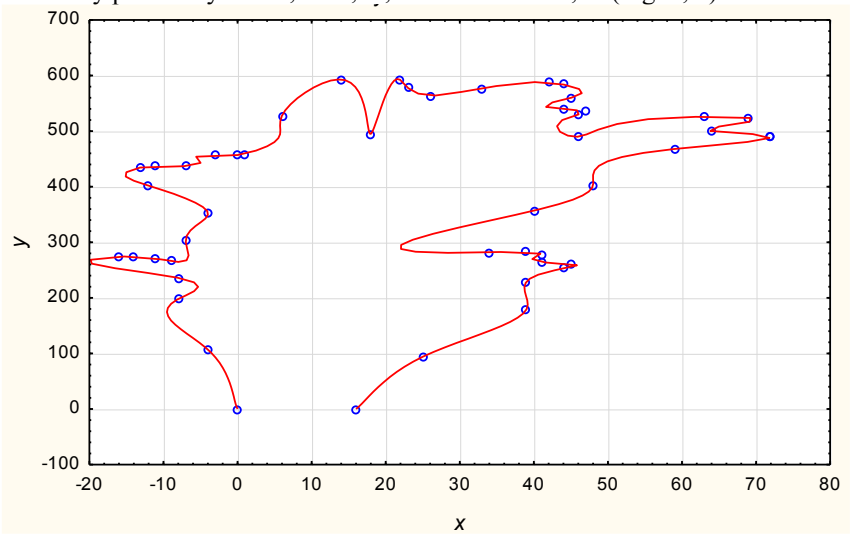
a

b

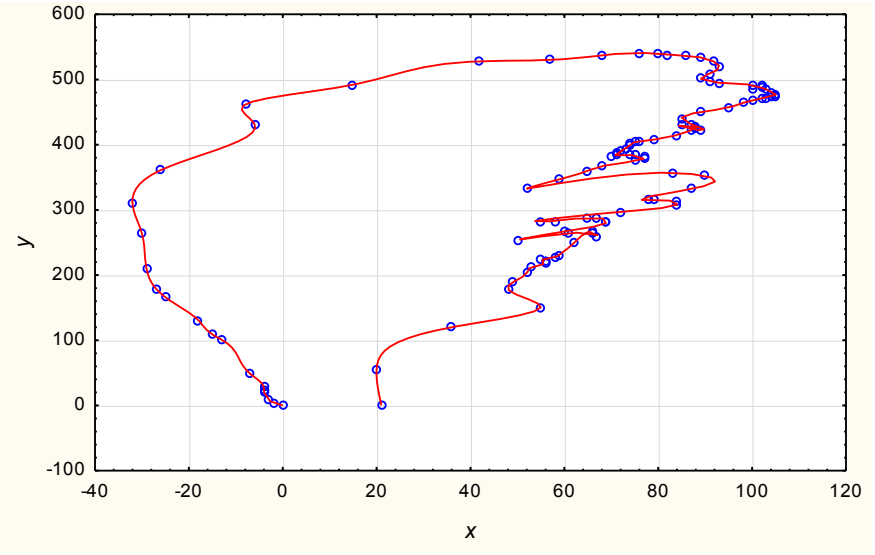
Fig. 2. Reed panicles: a – wet; b – dry.

In order to model the shape of wet and dry panicles, we outlined their perimeter.

Then we determined the coordinates of the obtained line in KOMPAS-3D program and approximated experimental data in Statistica program for wet panicles (Fig. 3, a). Regression equation for wet panicles y = 338,85 + 2,03x; correlation r = 0,34. Regression equation for dry panicles y = 175,7 + 2,7x; correlation r = 0,69 (Fig. 3, b).



a



b

Fig. 3. Scatter diagram with spline fitting of panicles: a – wet; b – dry.

We measured reed height in the near, middle and far edges of the channel from the ground to the lower point of the panicle (h_1, h_2, h_3, respectively) and from the ground to the upper point of the panicle (H_1, H_2, H_3, respectively).

The variation of height to the lower point of the panicle has mean values from 11 to 14 %, which is the average variation of the trait.

When designing the spray boom, we accept h_1 = 160, h_2 = 172 and h_3 = 179 cm.

Figure 4 shows the surface plot for h_1, h_2, h_3.

The resulting surface has the form $h_3 = 282,27 + 1,56h_1 – 3,3h_2 – 0,05\ h_{12} + 0.08h_1h_2 – 0,03h_{22}$.

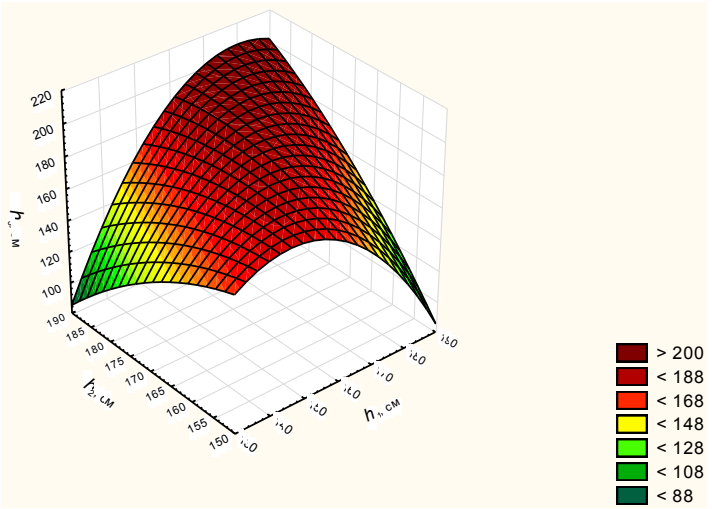


Fig. 4. Surface graph for h_1, h_2, h_3.

The variation of height to the upper point of the panicle has average values from 11 to 13 %, which is the average variation of the trait.

When designing a sprayer boom we take $H_1 = 188$, $H_2 = 195$ и $H_3 = 210$ cm.

Figure 5 shows the surface graph for H1, H2, H3. The resulting surface has the form $H_3 = 1297,7 – 44,7H_1 + 31H_2 – 0,2\ H_{12} + 0,6H_1H_2 – 0,4H_{22}$.

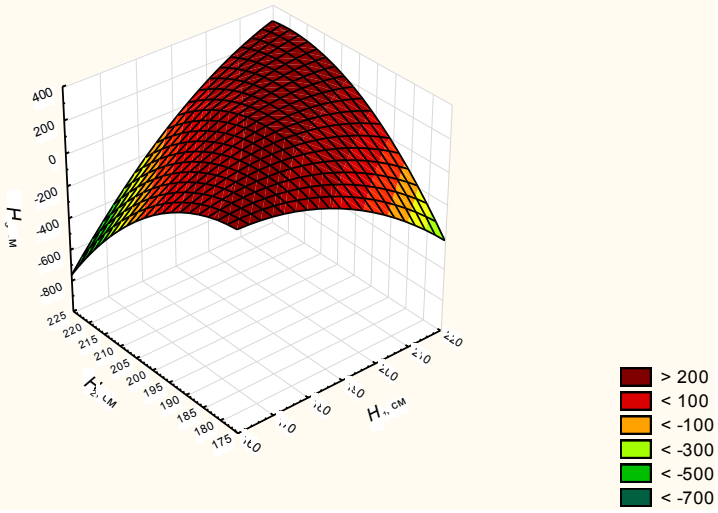


Fig. 5. Surface graph for H_1, H_2, H_3.

The location of the upper points of the panicles can be expressed by the equation $y = 186,5x^{0,0956}$, of the lower points of the panicles – $y = 160,06x^{0,1024}$.

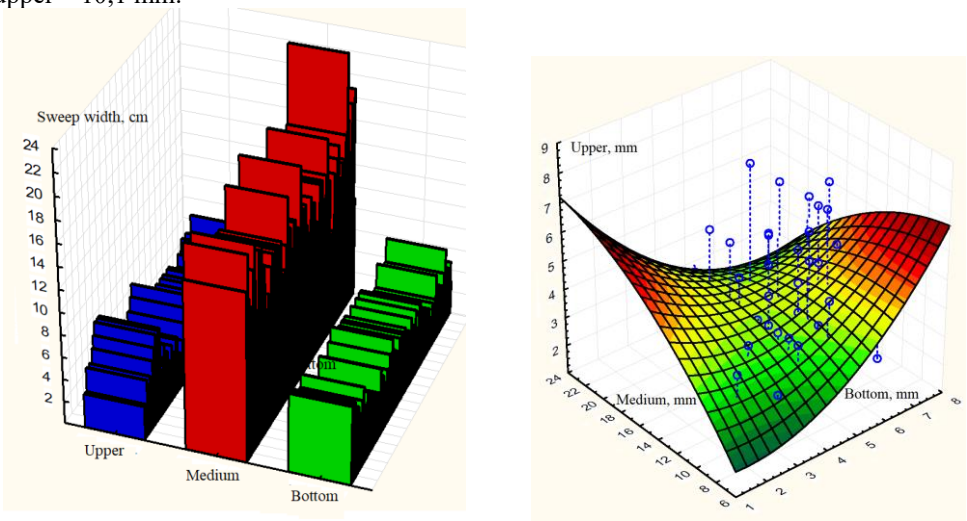
The number of panicles was measured by the width of reed growth in the channel. The average value of the number of panicles is 17 pcs, the coefficient of variation is 13 %.

The average value of the distance between the panicles in the width of the canal is 25 cm with a strong variation of this feature of 71 %.

To determine the treatment zone, the width of wet and dry panicles in the vertical position in the lower, middle and upper parts was determined (figure 6). The surface equation for wet panicles is $z = -1{,}92 + 0{,}18x + 0{,}74y + 0{,}11x^2 - 0{,}08xy - 0{,}01y^2$; dry – $z = 9{,}49 - 4{,}28x + 0{,}61y + 0{,}38x^2 + 0{,}01xy - 0{,}01y^2$.

As a result of studying the dimensional characteristics of the reeds, the following values can be assumed for the design of the proposed sprayer:

- The height from the ground to the bottom point of the pan at the near, middle, and far edges of the rice check channel is 160, 172, and 179 cm, respectively;
- height from the ground to the upper point of the panicle at the near, middle and far edges of the rice check channel is 188, 195 and 210 cm, respectively;
- the width of reed spreading in the channel is 374 cm;
- number of panicles across the width of the canal – 17 pcs;
- distance between the panicles across the width of the canal – 25 cm;
- length of wet panicles – 34–42 cm;
- length of dry panicles – 31 cm
- width of wet panicle in vertical position in the lower part – 4,2–4,8 mm; in the middle – 13,4–167,5 mm; in the upper part – 4,0–16,8 mm;
- width of dry panicle in vertical position in lower part – 5,4 mm; average – 29,6 mm; upper – 10,1 mm.



a b

Fig. 6. Scatter diagram with spline fitting of panicles: a – wet; b – dry.

The boom of our proposed sprayer has an original shape, sprayers which are located along the path of a parabola, taking into account the placement of the upper points of the panicles across the width of the channel (Figure 7).

Fig. 7. Experimental sprayer installation.

In order to create a zone of intensive local treatment of panicles with a minimum of working solution on the surface of the channel, the boom design includes a special protective chamber device that provides additional air-liquid flow during the movement of the sprayer.

To design a boom based on a study of the results of measurements:

- Length of wet panicles – 34–42 cm;
- length of dry panicles – 31 cm;

Based on the study of dimensional characteristics of the panicles, the zone of intensive treatment of the panicles should be at least 40 cm.

In the construction of protective-chamber device we use the principle of Archimedes' spiral, i.e. a set of points participating simultaneously in two uniform movements – along a straight line and on a circle. During the construction, the step a, equal to the radius of the circle (we take the diameter to be not less than 40 cm), is set. Offset of the center of the spiral from the axis of the spray nozzle vertically is equal to the step of the spiral a = 20 cm, which provides whirling and formation of air-liquid flow when the sprayer is moving. Distance from the place of attachment of the sprayer to the lower zone of treatment of panicles is 2a = 40 cm.

This design ensures uniform and local treatment of the cane panicles.

Protective chamber device 14 (Figure 8) has the form of an Archimedes spiral with a spiral pitch equal to at least a = 20 cm, the offset of the spiral center from the axis of placement of the spray tip vertically equals the spiral pitch a = 20 cm, and from the mounting location of the spray tip 18 to the lower zone of processing panicles 2a = 40 cm.

The unit moves along the perimeter of the check with the recommended speed. From the spraying nozzle under pressure the working liquid is supplied, which is involved in circular motion in the protective chamber device, which protects from the pesticide in the channel by creating a zone of intensive treatment of panicles.

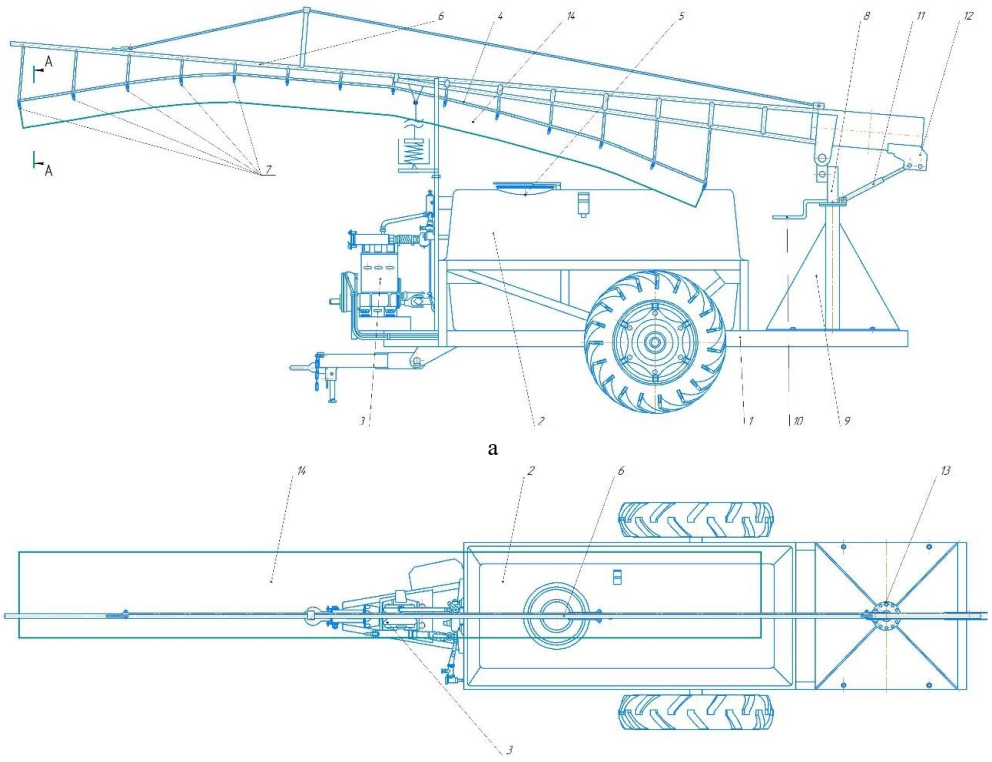


Fig. 8. Sprayer: a – left side view; b – top view; 1 – frame; 2 – tank; 3 – pump; 4 – hydraulic system; 5 – cleaning system; 6 – rotary boom; 7 – sprayers; 8 – rack; 9 – support; 10 – handle; 11 – hydraulic cylinder; 12 – flange; 13 – pin; 14 – guard-chamber device.

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