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GROUNDING THE PARAMETERS OF THE PNEUMATIC DEVICE FOR PESTS COLLECTING

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Summary. The article presents a system of pneumo-mechanic devices for ecologically clean plants care. Some of the main construction parameters of a pneumatic device for pests collection have been grounded.

Key words: Colorado potato beetle, pipe, working chamber

INTRODUCTION

Pests badly damage the harvests of potatoes, tomatoes, aubergines [Hare 1980, Khelifi *et al.*2007]. According to some data they cause harvest loss up to 30%. Manual collecting of pests is possible only on small districts and is inefficient for it should be done on a regular bases [Misener *et al.* 1993].

Chemical protection could be considered as a better choice but it has well-known drawbacks. The first is adaptability of pests to chemicals and necessity of change. The second is that the applied chemicals are extremely poisonous and human reaction to them has not been properly investigated (which contradicts the information in ads).

The pneumatic device for pests collection has been constructed in PSAU. This device has none of the above mentioned drawbacks. The offered technological scheme of a combined device consists of the following elements: pneumocollector 1, suctioning 2 pumping 3, ventilator 4, cultivator 5, destruction mechanism 6, tractor 7 (Fig. 1.) [Gucol *et al.* 2005a, Nowak *et al.*2006].

The device includes a Π – like ramp 7 in which there are horseshoe-shaped working cameras 8. Along the lower edges of the working cameras there are V-form pockets, one-side 9 along the edges of the ramp, and two-side pockets 10 in the inside. Every pocket is linked to the suctioning small pipes 11, groined to the collecting pipe 12. They are situated in the upper parts of the working cameras and groined together by the central pipeline 2. The front part of every working camera has a blowing device that is a pumping pipe 13 (the front support of the ramp) with a side jet 14 to every camera. In the back part of the working camera there is a rubber ribbon cleaner 15, and in the front part there are guidings from the collector 16 (Fig.2.) [Gucol *et al.* 2005a, Pat. 8746 A Ukraina. 2005].

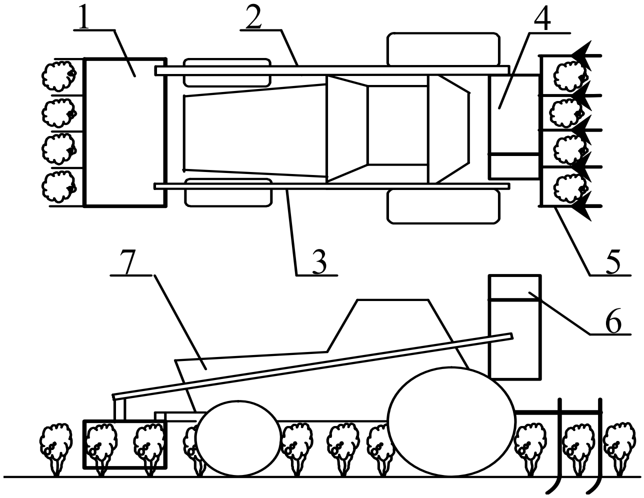

Fig. 1. Technological scheme of the device

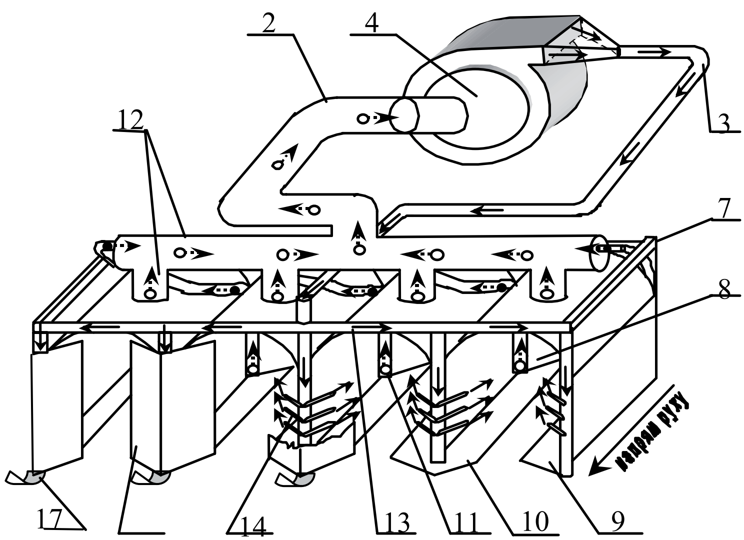

Fig. 2. Pneumatic device

The device works like this. While moving the guidings of the device the plants are lead to the camera for pests collecting. When in the front part of the device, plants are subjected to the down-up air force. Partly blown-off pests get to the pockets and then to the central suctioning pipeline. The camera moving over the central part of the bush, the process of suctioning the pests by the cone collector and into the vertical pipeline, takes place. When the bush leaves the camera the pests are mechanically shaken from it by rubber ribbons. The process of blowing the air and suctioning is done by the ventilator. As laboratory experiments showed, the efficiency is gained by optimizing the form of the camera and adjusting the strength of air stream. The work suggests the grounding of the device's parameters. Calculation scheme is offered in Fig 3.

MATERIALS AND METHODS

To get the best absorbing camera form, we consider the bush (average) in the calm state as a cut cone (stems) and half-sphere (foliage). Parameters of both con and sphere depend on the sort and stage of plant's growing. The absorbing air-stream changes the shape of the bush (the angle in the bases of the cone lessens and half-sphere changes into the ellipsoid). As the experiments show, the main part of the shaken pests get into the space of the camera and for their free flight between the re-shaped bush and the camera there must be some distance.

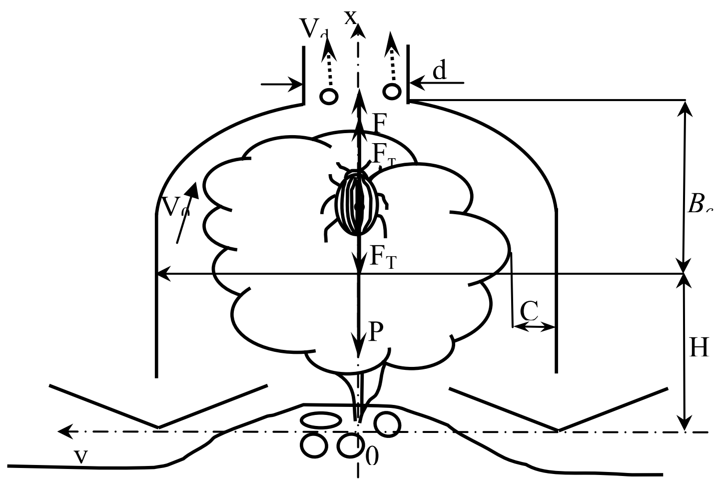

Fig. 3. Calculating scheme

Contemporary uncomplicated calculations allow getting the following equation for the form of the upper chamber [Ęvdokimov 1983, Gucol *et al.* 2005a, Gucol *et al.* 2006]:

$$\frac{x^2}{\left(R+\Delta R+C_o\right)^2}+\frac{y^2}{\left(R-\Delta R+C_o\right)^2}=1 \tag{1}$$

where: ΔR – deformation of the sphere shape of the bush,
R – radii of the non-deformed sphere.

One of the main factors of the pneumatic device is the moving of pests into the upper part of the device. Let us investigate the dynamics of the pest's flight in the air stream (passive conditions–the wings are not open).

Let us model the pest as a three-axis ellipsis with half-axis a, b, c, whereas without loosing the generalization we can state that a>b>c. The volume of the ellipsis and the area of the transverse crossings along the surface of symmetry are presented by the following consecutive expressions:

$$V = \frac{4}{3}\pi \cdot a \cdot b \cdot c\,; \; S_{xy} = \pi \cdot a \cdot b\,; \; S_{xz} = \pi \cdot b \cdot c\,; \; S_{yz} = \pi \cdot a \cdot c \tag{2}$$

The pest torn off the plant is influenced by such forces:

a) the power of weight P, b) Archimedes power F_A, c) the power of air's counteract F_T, d) frontal counteract F.

$$P = m \cdot g = V \cdot \rho \cdot g\,; \; F_A = V \cdot \rho_n \cdot g\,; \; \mathrm{F_T} = \beta \cdot S \cdot (v_0 - v);\; \mathrm{F} = \frac{\rho_n \cdot (v_0 - v)^2}{2} \cdot S \tag{3}$$

ρ – here are mentioned,

ρ_n – the average of the pest body density,

β – the density of air,

S – coefficient of pest friction with the air of the area of pest cross-section, which is perpendicular to the vector of the air stream speed.

Let us put down the dynamic equation of the pest's moving in the air Ox:

$$mV = V \cdot \rho_n \cdot g + \frac{\rho_n (v_0 - v)^2}{2} \cdot S - m \cdot g - \beta \cdot S \cdot (v_0 - v) \tag{4}$$

The condition of pest moving upwards is the following

$$V \cdot \rho_n \cdot g + \frac{\rho_n \cdot (v_0 - v)^2}{2} \cdot S \rangle V \cdot \rho \cdot g + \beta \cdot S \cdot (v_0 - v) \tag{5}$$

$$v_0 \rangle + \frac{\beta}{\rho_n} \cdot \left(1 + \sqrt{1 + \frac{8}{3} \cdot \frac{a \cdot g \cdot \rho_n}{\beta^2} \cdot (\rho - \rho_n)}\right) \tag{6}$$

The condition of the least area is chosen here (S_{xy} in (2)). It is (6) simplified if Archimedes power and the power of counteraction are not considered. Then:

(7)

As the number assessment of min air speed show, they have the value v ≈ 8 m/s [Gucol *et al.*2005b, Gucol *et al.* 2006].

Let's change the equation (4) into the one, convenient for further analysis

$$y - d \cdot y^2 - \delta \cdot y = \lambda$$

$$y = v - v_0\,; \; \alpha = \frac{3}{8 \cdot a} \cdot \frac{\rho_n}{\rho}\,; \; \delta = \frac{3 \cdot \beta}{4 \cdot a \cdot \rho}\,; \; \lambda = \left(1 - \frac{\rho_n}{\rho}\right) \cdot g \tag{8}$$

RESULTS AND DISCUSSION

It can be considered that the air stream picks the pest up [Lacasse 1998]. Having taken it up creates the zero beginning conditions. The solution of the equation (8) is possible and are for any amount of parameters in the analogical way. Let us put down the solution for the actual case of small amounts of air density (δ<<1) and ($\rho_n << \rho$):

$$v_t = v_0 + \sqrt{\frac{8 \cdot a}{3} \cdot \frac{\rho}{\rho_n} \cdot g} \cdot \left[\sqrt{\frac{3 \cdot \rho_n}{8 \cdot a \cdot \rho \cdot g}} v_0 + tg \sqrt{\frac{3 \cdot \rho_n}{8 \cdot \rho} \cdot \frac{g}{a}} \cdot t \right] \cdot \left[1 - \sqrt{\frac{3 \cdot \rho_n}{8 \cdot a \cdot \rho \cdot g}} \cdot v_0 \cdot tg \sqrt{\frac{3 \cdot \rho_n}{8 \cdot \rho_1} \cdot \frac{g}{a}} \cdot t \right]^{-1} \quad (9)$$

The analysis (9) of the expression reveals the pest's flight as pulsating in character with period of T and amplitude value V_a.

$$\grave{O} = \frac{2}{\pi} \cdot \sqrt{\frac{2 \cdot a \cdot \rho}{3 \cdot \rho_n \cdot g}}; \; v_a = v_0 \cdot \left[1 \mp \frac{8 \cdot a \cdot \rho \cdot g}{3 \cdot \rho_n \cdot V_0^2} \right]; \quad (10)$$

If the length of the sucking device is L and the diameter of the sucking pipe is d, then the min speed of the air stream movement in the pipe is calculated by

$$v_a = \frac{8}{\pi} \cdot \frac{a_0 \cdot L}{d^2} \cdot v_0 \quad (11)$$

Theoretical calculations allow to suggest that the most effective form of the suctioning camera is the horse-shoe form, as then the device work is the most effective and energy consumption rate is the lowest. It should be mentioned that the above-mentioned problems allow different modifications and elaboration. So the models can be considered as multi-level.

Finally, application of pneumatic method of collection of insect-wreckers can allow to give up chemical till of plants and get net products, to reduce expenses in agriculture, to eliminate wreckers and also, last but not least, to lower morbidity of workers dealing with chemical till of plants.

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