IOP Conference Series: Earth and Environmental Science

Modelling the process of local application of manure under glass crops

To cite this article: A Li *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **868** 012008

Modelling the process of local application of manure under glass crops

A Li, B Sultanov, Z Sharipov, N Umirov

Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, st. Corey Niyazi, 39, Tashkent, 100000, Republic of Uzbekistan

E-mail: as_lee@mail.ru

Abstract. The main lever for the production of an environmentally friendly product and an increase in crop yields, as well as a constant increase in soil fertility, as shown by domestic and foreign experience, is the use of organic fertilizers. At present, for all agricultural crops, including melons and gourds, organic fertilizers are mainly applied for plowing with manure spreaders. However, in relation to melon crops, such application technology is both irrational and uneconomical. This is explained by the fact that melons and gourds are cultivated on wide (from 1.8 m to 4.0 m) aisles. Therefore, when spreading (continuous) method of application, a significant part of the manure is not used by plants. Consequently, one of the main tasks of agricultural science is the creation of fundamentally new technological processes and machines that provide a significant increase in the efficiency of fertilizer use. Theoretical studies were carried out using the general laws of mechanics, mathematical modeling, taking into account the technological features of the application process and the physical and mechanical properties of manure. Studies show that the speed of the manure mass lags behind the speed of the spreader's chain-slat conveyor, therefore, when calculating the productivity, a correction factor Ko = 0.5 ... 0.6 should be introduced. The lower value corresponds to the minimum feed and the upper limit to the maximum. To divide the manure flow into three equal parts, it is necessary to install the dividers at a height of 0.64 m and the speed of the belt conveyor in the range of 0.25 ... 0.44 m / s.

1. Introduction

Currently, agronomic science and best practices have proven that one of the rational ways to use fertilizers is to apply them in rows, nests or wells, i.e. locally. Fertilization is an integral part of plant nutrition, it covers a wide range of issues related to the optimal location of all types of fertilizers in the soil to ensure maximum satisfaction of plant needs at various points of the growing season [1, 2].

In connection with the above, one of the main tasks of agricultural science is the creation of fundamentally new technological processes and machines that provide a significant increase in the efficiency of fertilizer use [3].

The purpose of the research is to analyze the interaction of the working bodies of the manure spreader and the device for local application of manure to justify its parameters and operating modes that ensure a high-quality technological process of work.

2. Materials and methods

Theoretical studies on the justification of the parameters of the device for belt application of manure were carried out using the general laws of mechanics, mathematical modeling and statistics, taking into account the technological features of the application process and the physical and mechanical properties of manure [4,5,6,7].

3. The discussion of the results

Chain-slat conveyors of mobile manure spreaders, located in the body, are a type of continuous drawing conveyors, in which the working body is completely immersed in the transported bulk cargo, filling the entire useful space of the spreader body. Therefore, for these conveyors, the laws of motion of bulk solids can be applied when transporting them by the method of continuous drawing.

The supply of manure by a chain-slat conveyor in practical calculations is determined by the formula [4, 5]:

$$q = \gamma \cdot H_y \cdot B_k \cdot V_{ts.pl.tr} \tag{1}$$

where γ – bulk density of manure, kg/m^3; H_y – height of the manure feed layer, m; B_k – body width, m; $V_{ts.pl.tr}$ – conveyor speed, m/s.

The speed of the chain-slat conveyor is determined from the condition of the required amount of manure per unit length of the roll (belt) [3]:

$$V_{ts.pl.tr} = (V_a q_l / 3{,}6 q_k) n \tag{2}$$

where V_a – unit speed, m/s; q_l – amount of manure per meter of the roll length in kg; q_k – amount of manure per meter of the body length in kg; n - number of simultaneous insertion of strips of manure.

However, the theoretical flow rate, calculated by the formula (1) is untrue, as the formula does not take into account the actual feed rate of manure, which lags behind the speed of the conveyor all the way to move it [8, 9, 10, 11].

Due to the fact that the manure layer is in motion, its height decreases due to collapses when the upper layers slip relative to the lower ones. In this case, the speed of the lower layer of manure along the height of the plank is numerically equal to the speed of the conveyor plank itself, and the speed of the upper layer is approximately zero (Fig. 1).

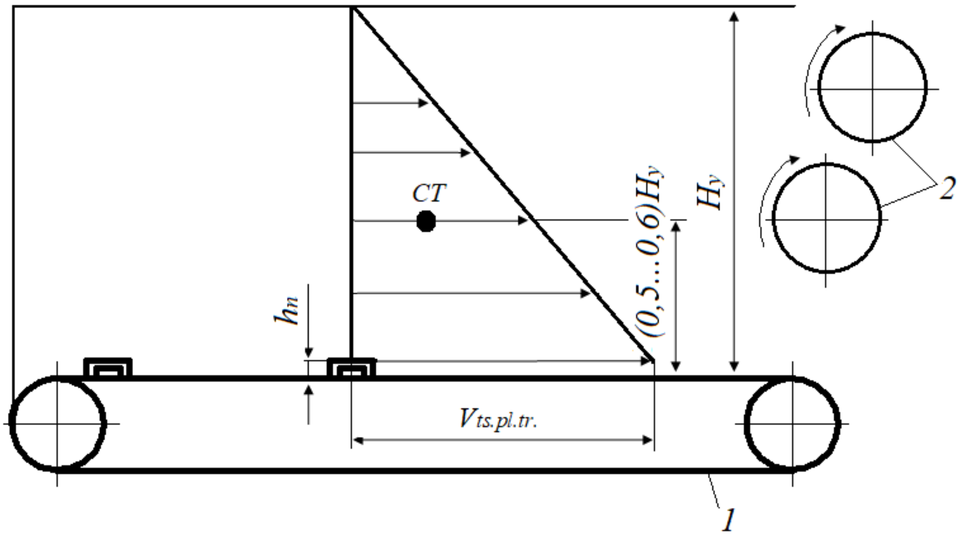

Figure 1. The pattern of manure movement in the body under the action of conveyor slats:
1 – chain-slat conveyor; 2 – chopping and scattering drums

According to Figure 1, the average speed of movement of the mass of manure along the height of the body is close to the speed of the center of gravity of the velocity plot. The center of gravity of the velocity plot, taking into account the decrease in the height of the manure layer from the joint actions of the static collapse along the angle of the natural slope and the movement factors, is determined from the expression [3]:

$$H_s = (0,5 \dots 0,6)H_y . \tag{3}$$

Experimental studies have established that the application rate of manure (20 t/ha), the maximum load of the machine (4650 kg), the speed of the unit (V_a = 1.81 m/s) the actual unloading of the body with a length of 4.15 m is 195±2 s, including the velocity of the mass (0,021 m/s) [12, 13, 14].

The theoretical speed chain-slatted conveyor, calculated according to expression (2) for the width of the machine (V_m = 4.2 m) is equal to 0,041 m/s and unloading of the body with 101.22.

The calculations made it possible to establish that the average speed of movement of the mass of manure is twice lower than the speed of the conveyor. It follows that when determining the performance of mechanisms that feed manure from the body using a chain-slat conveyor, it is necessary to make an amendment - a coefficient that characterizes the degree of lag of the mass of manure from the moving conveyor:

$$K_0 = \frac{V_n}{V_s} = 0,5 \dots 0,55 \tag{4}$$

where V_n – actual speed of movement of the mass of manure, m/s.

Taking into account the expression (4), the formula for determining the feed by a chain-slat conveyor that is stable throughout the entire time of emptying the body will take the form:

$$q = \gamma \cdot \gamma \cdot H_y \cdot V_s \cdot K_0 . \tag{5}$$

Further, the manure fed by the chain-slat conveyor, through a special device, is applied locally in three rows (tapes) to the soil surface. However, it should be noted that all three feed belts of the fertilizer flow have significant differences in weight, which greatly affects the uniformity of distribution and reduces the efficiency of their use, respectively [14, 15, 16, 17].

This is due to the design of the shredding and spreading beaters of the manure spreader. Therefore, for a more uniform application of manure, special dividers are installed behind the beaters of the manure spreader inside the housing of the device (Fig. 2).

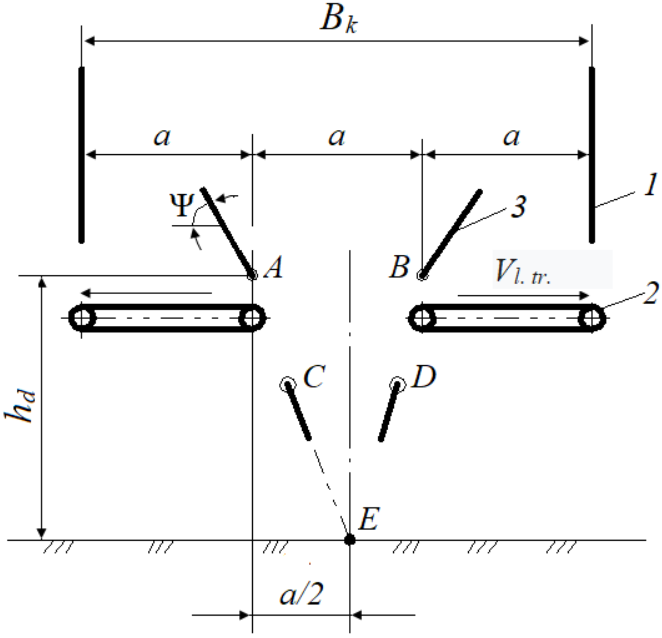

Figure 2. Installation height of dividers: 1 – extension casing; 2 – remote conveyor belt; 3 – dividers

However, at $\psi \leq \varphi$, where φ is the angle of friction of the fertilizer particles on the metal, manure can stick to the surface of the dividers. Therefore, for a uniform distribution of the fertilizer flow into three parts, the following condition must be met:

$$\Psi < \varphi < 90°. \tag{6}$$

The necessary uniformity of the distribution of the fertilizer flow can be achieved by a rational combination of the angle (ψ) of the installation and the length of the dividers, which can be established experimentally. The uniformity of the distribution of the fertilizer flow is also affected by the location and angle of the trays (for sowing the middle row). Condition (6) also applies to them, but it is necessary that the trays direct the fertilizer particles to the middle of the belt, i.e. to the point *E*. For a reliable flow of the technological process, the following condition must be met:

$$\Psi = arctg\frac{2h_d}{a} \tag{7}$$

where a – distance between two points of attachment of dividers, m. With known values of the installation angle (ψ = 60°) the distance between the lower points of attachment of the dividers is equal to 600 mm:

$$h_d = 0{,}64\,m$$

Remote belt conveyors of the device, as noted above, perform the function of working bodies for applying the extreme (side) rows of manure to the soil surface. The second feed of each of the remote conveyors is equal to 1/3 of the total mass of the fertilizer applied by the manure spreader, respectively.

The required second feed of manure by one remote conveyor can be determined by knowing the technological speed of the unit, the width of the machine and the rate of manure application [3]:

$$q_{\text{tp}} = [B_m \cdot V_a \cdot Q \cdot 10^{-1}]/n \tag{8}$$

where B_m – machine grip width, m; V_a – forward speed of the unit, m / s; Q – fertilizer application rate, t/ha; n – the number of simultaneously applied rows of manure. With local application of manure for melon crops, the width of the row spacing at the base of the rows of fertilizers is $S_l = 1{,}2\ m$ [3].

Therefore, the total width of the machine taking into account the width of the butt aisles is equal to:

$$B_m = (n-1)\cdot(S_l + S_p)$$

where S_l – width of row spacing at the base of fertilizer belts (rolls), m; S_p – the width of the butt row spacing, m. Based on this, the expression (8) can be represented as follows:

$$q_{tp} = \{[(n-1)S_l + S_p]/n\}\,V_{\text{a}} \cdot Q \cdot 10^{-1}. \tag{9}$$

On the other hand, the desired second feed of manure can be determined based on the parameters and operating mode of the remote conveyor itself:

$$q_{tp} = V_{l.sr} \cdot \text{В}_s \cdot h_s \cdot \gamma \cdot \text{К}_g \tag{10}$$

where $V_{a.}$ – linear speed of the remote conveyor belt, m / s; B_s – width of the outlet slot (window), m; h_s – height of the outlet slot (window), m; K_g – coefficient that characterizes the degree of filling of the remote belt conveyor of the device (K_g = 0,85…0,95).

The speed of the conveyor should be determined from the condition of the required amount of manure per unit length of the belt, i.e. from the equality of expressions (9) and (10) we find the linear speed of the belt of the remote conveyor:

$$V_{l.tr} = \frac{V_a \cdot Q \cdot 10^{-1}}{\text{В}_s \cdot h_s \cdot \gamma \cdot \text{К}_g}\{[(n-1)S_l + S_p]/n\}. \tag{11}$$

Width of discharge opening:

$$\text{В}_s = \text{В}_{tr} - 2b_p \tag{12}$$

where B_{tr} – conveyor belt width, m; b_p – width of the clamping strip of the remote conveyor belt, m.

According to experimental data $B_{tr.}$ = 0,5 m, b_p from practice, it is taken to be equal to 0.020 m. Using the accepted parameter values and the constraints included in formula (11), we obtain:

$$V_{l.tr} = 0{,}25 \ldots 0{,}44\ m/s.$$

If we assume that all the parameters included in equation (11) are constant values, then the rate of application of the device can be changed by changing the height of the outlet slot.

4. Conclusion

On the basis of theoretical studies, taking into account the physic mechanical properties of organic fertilizers, analytical dependences have been obtained that make it possible to determine some setting parameters - the installation height of the divider is not less than 0.64 m and the speed of the belt conveyor is 0.45 m/s.

References

[1] Lozanovskaya I N, Orlov D S, Popov P D 1987 *Theory and practice of using organic fertilizers* (Moscow: Agropromizdat)

[2] Dannikov V D, Mineev V G 1987 *Soil, climate, fertilizers and crops* (Moscow: Agropromizdat)

[3] Rasulov A, Azimbaev S 1984 *Increasing the fertility of irrigated soils in Uzbekistan* (Tashkent: Uzbekistan)

[4] Targ S.M. 1986 *Theoretical Mechanics Course* (Moscow: Science).

[5] Kuhn T 1998 Density matrix theory of coherent ultrafast dynamics *Theory of Transport Properties of Semiconductor Nanostructures* chapter 6, pp 173–214 (London: Chapman and Hall)

[6] Korn G, Korn T 1990 *Handbook of mathematics for scientists and engineers* (Moscow: Science)

[7] Akalis P 1995 *Handbook of elementary mathematics, mechanics and physics.* (Moscow: Science)

[8] Artobolevsky I I 1988 *The theory of mechanisms and machines.* (Moscow: Science)

[9] Doganovsky K G, Kozlovsky E V 1976 *Fertilizing machines. Design, theory, calculation and testing* (Moscow: Kolos)

[10] Marchenko N M, Lichman G I, Shebalkin A E 1990 *Mechanization of organic fertilization* (Moscow: Agropromizdat)

[11] Barefoot E S, Vernyaev O V 1978 *Theory, design and calculation of agricultural machines. Mechanical engineering* (Moscow: Science)

[12] Karpenko A N, Khalansky V M 1989 *Agricultural machines* (Moscow: Agropromizdat)

[13] Lee A, Usmonov T, Norov B 2020 Seiling and cleaning of channels *IOP Conference Series: Materials Science and Engineering* ***883*** *012062 doi: 10.1088 / 1757-899X / 883/1/012062)*

[14] Mirzaev B, Mamatov F, Chuyanov D, Ravshanov H, Shodmonov G, Tavashov R, Fayzullayev X 2019 Combined machine for preparing soil for cropping of melons and gourds *IOP Conference Series: Earth and Environmental Science,* ***403*** *DOI: 10.1088/1755-1315/403/1/012158*

[15] Astanakulov K D, Fozilov G G, Kodirov B K, Khudaev I, Shermukhamedov K, Umarova F 2020 Theoretical and experimental results of determination of the peeler-bar parameters of corn-thresher. *IOP Conference Series: Earth and Environmental Science* ***614 (1)*** *DOI: 10.1088/1755-1315/614/1/012130*

[16] Lee A, Usmonov T, Norov B, Melikuziev S 2020 Advanced device for cleaning drain wells. *IOP Conference Series: Materials Science and Engineering,* ***883 (1),*** *012181, DOI: 10.1088/1757-899X/883/1/012181*

[17] Bazunov G V 1989 *Study of the working process of the chain-slat conveyor to substantiate the design parameters of the manure spreader*. Cand. tech. Sciences PhD (Moscow: VIM).

[18] Astanakulov K D, Karimov M R, Khudaev I, Israilova D A, Muradimova F B 2020 The separation of light impurities of safflower seeds in the cyclone of the grain cleaning machine *IOP Conference Series: Earth and Environmental Science,* ***614 (1)****. DOI: 10.1088/1755-1315/614/1/012141*