# THE JUSTIFICATION FOR COLTER SPREADER CONFICURATION SELECTED FOR BROADCAST SEEDING AND MINERAL FERTILIZER APPLICATION

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***Abstract:*** *The aim of this work the graphical regularities of the fertilizer pellets outflow through a flattened cone have been considered in an effort to justify the configuration of universal colter spreader which would provide even distribution of the grass and grain seeds, and mineral fertilizer pellets within the soil. It has been determined that to achieve the granular materials' uniform outflow in the direction transverse to travel speed over the colter spreader surface its elliptical cross-section is required. To this effect the section plane should be directed perpendicular to travel speed, cross over all cone generators at an angle between it and central axis of the latter other than* $\pi/2$.
***Keywords:*** *colter, broadcast seeding, mineral fertilizers, spreader, grass sowing, fertilizer applicator.*

Research analysis shows that broadcast subsoil seeding method creates the most vavorable conditions for growth and development of cultivated crops [1, 2, 3]. This is due to more even distribution of seeds over the field than that in the row seeding method [4, 5]. Thus, at broadcast seeding method the yield capacity of corn crops and grass at an average increases by 10…30% if compared with close-drilling and row seeding methods [6, 7, 8].

At broadcast seeding the best quality is assured by the seeding machines equipped with tine colters having spreaders for broadcast subsoil seeding which evenly distribute the seeds throughout all field area [9,10]. Passive spreader of various configurations is the most common and simple in design. However, such spreaders are characterized by highly irregular distribution of seeds and fertilizer pellets by the grasp width [11,12]. Vibrating spreaders create low irregularity of the seed distribution but their design is more complicated.

It is known from analysis of various methods of positional application of fertilizers in the soil that in order to minimize the fertilizer absorption by soil and to create conditions for the plants' better access to them in risky agriculture environment of North Kazakhstan the using screen method for local application of the main fertilizer dose for grain crops to 10…15cm depth of permanent moisture.

To implement the said technology various distribution devices and attachments are aplied. However, the existing distribution devices for internal soil application of mineral fertilizers equipped with passive spreaders do not provide the required (up to 15%) regularity of solid fertilizers screening [13].

In connection therewith, the work aimed to improve the regular distribution of various crop seeds and fertilizer pellets over the field area by means of improving the universal spreader design in under-tine space is of great topicality and practical significance.

**Goal of research** is to justify the configuration of universal cone – colter spreader providing even distribution of grass seeds, grain crops and mineral fertilizer pellets within the soil.

**Research objective:**

- research of regularities of fertilizer pellet outflow through the flattened cone.

**Materials and methods of research.**

According to *operational hypothesis* we have suggested, *in order to achieve the even band distribution of fertilizers the impact is required to stabilize the law of mineral fertilizer distribution at outlet from the colter shank and in under-tine space of the colter* [14].

If using the technical solution [15], which consists in that at the cone surface cutting off in directions transverse to movement, in parallel to the cone generator, the bottomscatterer edge has the parabolic curve shape and oval shape in the plan (in this case the material traces $1^1$-$2^1$, $2^1$-$3^1$, $3^1$-$4^1$ may be equal, figure 1), then it is possible to provide even distribution of the fertilizer pellets across the width of colter.

To realize the suggested hypothesis, for subsoil application of fertilizers the new colter design has been developed. The structure consists of fertilizer funnel shank to which the duck-foot tine or tine point is connected (at grass seeding). In the base of fertilizer funnel shank the spreader cone is fixed.

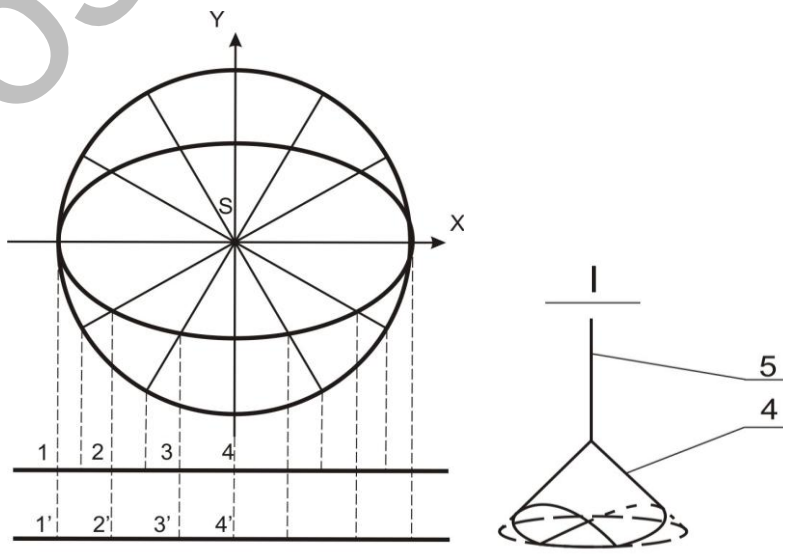


***Figure 1*** *– Cone scatterer, top view*

Essential prerequisite to achieve the even fertilizer pellets flowing down from cone is their falling into top part of the flattened cone. The spreader cone purpose consists in even distribution of materials in transverse direction of under-tine space.

**Research results and their analysis.** Figure 2 represents the scatterer cone with *S* vertex and *S-1, S-2,…,S-12* generators. Three projections, namely: front, horizontal and profile are shown in the figure. If the travel speed direction $\upsilon$ is taken by *Ox* axis then in profile projection the $S''' - 7''' - 1'''$ scatterer cone moves towards us, the lookers. Flowing down the cone generator the fertilizer particles fall into the $1''', 2''', \ldots, 6''', 7'''$. points. In the figure the fertilizer traces are shown by dash-dotted lines. As it is seen from the figure, the interval between the application traces are not equal and have the sizes of $\delta_1$, $\delta_2$ и $\delta_3$, though the fertilizers were delivered to the scatterer cone by equal angular spacing $\delta^o$.

The task is to make equal the unequal intervals $\delta_i$ between the traces of fertilizer particles drilling. For this purpose, we divide the cone scatterer base diameter *D* into six parts with equal intervals $\Delta$. The project traces of fertilizer particles drilling are reconstructed through the obtained 1, 2, …7 points. For differentiation they are drawn by dash lines. Let us determine the points of obtained drilling traces intersection with corresponding generators in the profile projection:

$$\begin{aligned} &Сл.1 \cap S'''1''' = L_1'''; && Сл.5 \cap S'''5''' = L_5'''; \\ &Сл.2 \cap S'''2''' = L_2'''; && Сл.6 \cap S'''65 = L_6'''; \\ &Сл.3 \cap S'''3''' = L_3'''; && Сл.7 \cap S'''76 = L_7'''. \\ &Сл.4 \cap S'''4''' = L_4'''; \end{aligned} \qquad (1)$$

Through the obtained points connecting by smooth lines we obtain the profile projection of unknown curve $L_1''', L_2''', \ldots, L_7'''$, which can provide regular outflow of the fertilizer particles over the scatterer cone surface in the transverse direction *z*. However, its form and the way to obtain it remain unknown.

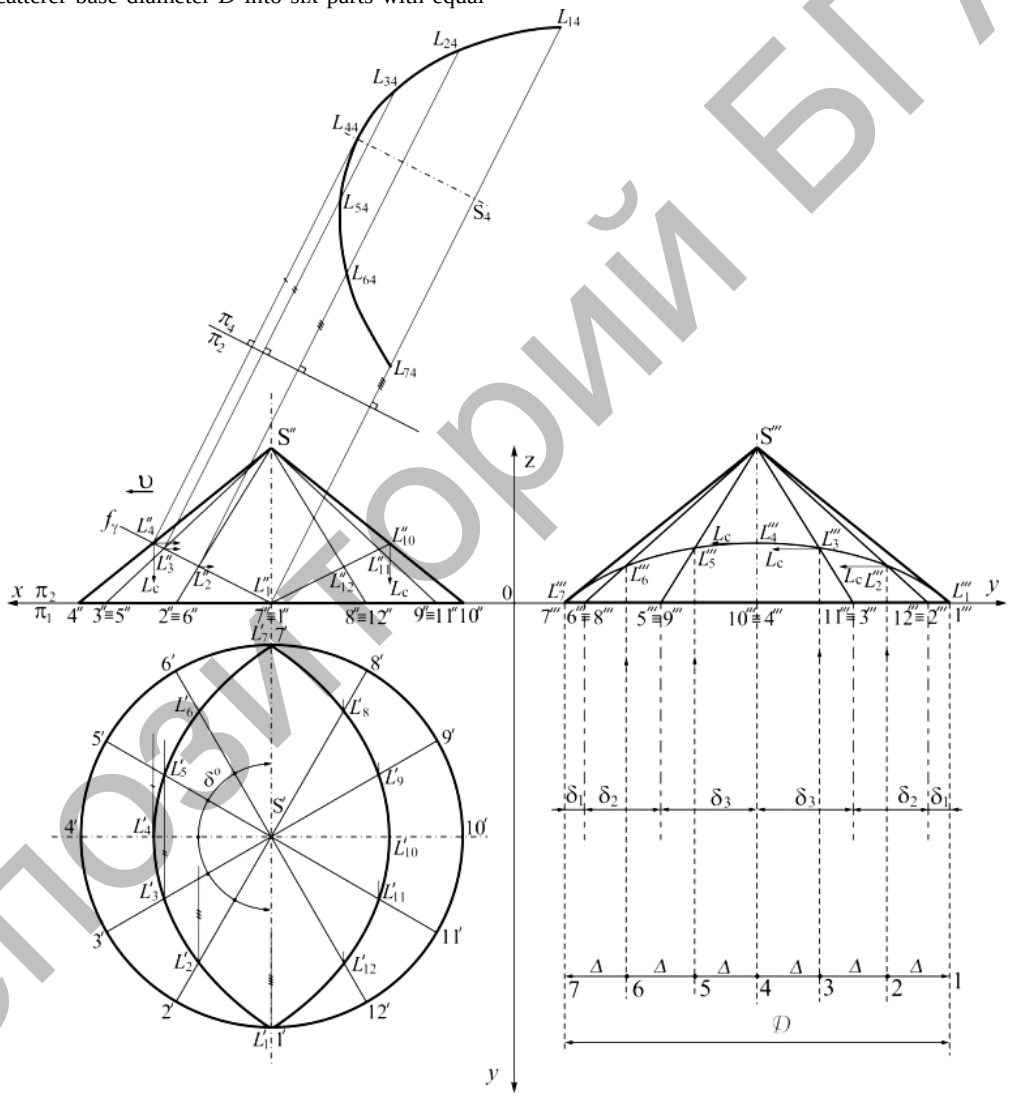


***Figure 2*** *– To rationale for the spreader cone configuration*

To determine the form of, and way of obtaining the desired curve let us project the $L_1''', L_2''', \ldots,$ points, as well as $L_4'''$, point located at the curve peak to corresponding generators of front projection. As it is seen from the figure, $L_1''$ remains in $1''$ point. In the cone backside $L_7''$ coincides with it. The remained points are determined at connection line (*Ls*) intersections with corresponding generators:

$$\Pi c\, L_2''' \cap S''2'' = L_2'';$$
$$\Pi c\, L_3''' \cap S''3'' = L_3''. \qquad (2)$$

Having $L_1'' - L_2'' - L_3''$ connected we obtain a straight line. It goes without saying that this line constitutes a front trace of frontally projecting plane $\gamma$, on which the desired curve is located. Further we determine:

$$f_\gamma \cap S''4'' = L_4''.$$

Back projection gives a point at the peak of desired curve:

$$\Pi c\, L_4'' \cap S'''4''' = L_4'''.$$

Cone is the surface symmetric with respect to its central axis. Therefore, the $L''_{10}$, $L''_{11}$ and $L''_{12}$ are determined according to symmetry law.

Horizontal projection of the desired line points is determined by means of the found front projections to corresponding cone generators on horizontal plane of the projection:

$$\Pi c\, L_2'' \cap S'2' = L_2';$$
$$\Pi c\, L_3'' \cap S'3' = L_3'. \qquad (3)$$
……..……..……..…..

However, the obtained projection does not give the comprehensive idea of the curve nature since it consists of two branches, at that, each branch is not represented in full.

To determine the natural form of desired curve let us use the descriptive geometry methods for projection transformation, particularly, the method of projection plane replacement. For this purpose, let us replace $\pi_1$ plane of initial system by $\pi_4$ plane of the new system. At that, the replacing plane should be parallel to $\gamma$ plane, as the desired curve lies on it:

$$(L_1, -L_2, -...)\frac{\pi_2}{\pi_1}\quad\frac{\pi_2}{\pi_4}(L_{14}, -L_{24} - ...) \| \pi_4. \qquad (4)$$

Based on the provision that coordinates in the replacing plane should be equal to coordinates in replaced plane, we determine the points $L_{14}, L_{24}, L_{34}$ and $L_{44}$. The desired figure is symmetric with respect to $S'4'$ generator. That is why the points $L_{54}, L_{64}$ and $L_{74}$ are determined according to the symmetry law.

Upon the obtained points connecting by smooth lines one may note that the desired curve constitutes a half of ellipse the major axis of which is equal to $b = L_{14} - L_{74}$, and minor axis is equal to $a = 2L_{44} - S_4$.

To confirm the reached conclusion let us consider the $\alpha$ cone with *S* vertex and rotation axis *i*. Some $\gamma$ - plane intersects all its generators but is not perpendicular to the cone axis. Thus:

$$\gamma \cap \alpha = l,$$

some curve line is obtained, figure 3.

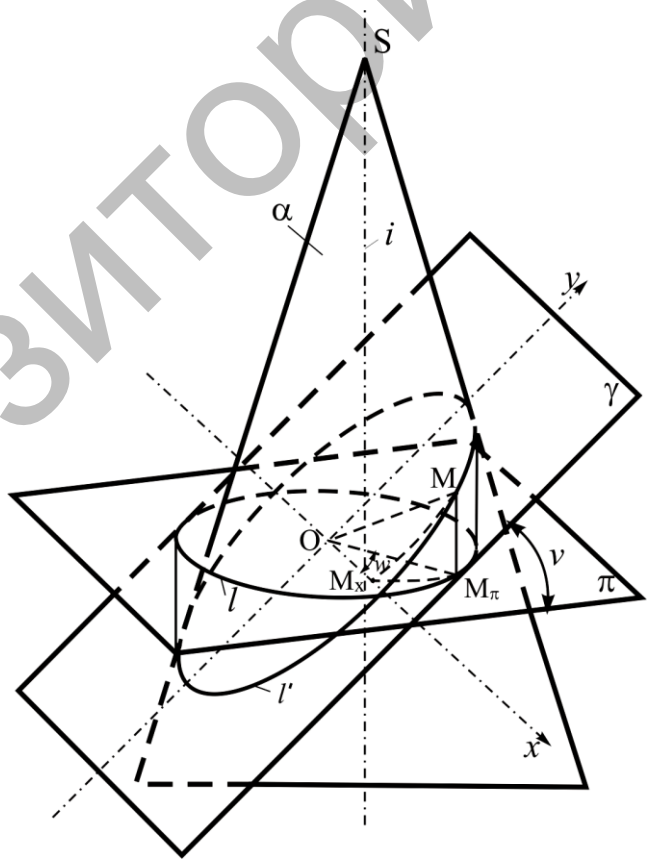


***Figure 3*** *– To rationale for the spreader cone configuration*

Let us project all pints of *l* curve to $\pi$ plane which is perpendicular to *i* axis of the cone. For example, the *M* point is projected to $M_\pi$ point.

The given cone is circular, therefore, on the $\pi$ plane the circle $l'$ of radius $a$ will be obtained. Its value is equal to the radius of cone on the plane $\pi$.

Let us draw through the center of circle $l$ the coordinate axis $oy$ in the $\gamma$ plane and axis $ox$ perpendicular to it. $M$ point coordinates on these axes are equal to:

$$x = OMx;$$
$$y = MMx. \qquad (5)$$

We take following notations:

$\nu$ – acute angle between the planes $\gamma$ and $\pi$;

*w* – angle between radius of circle $a = OM_\pi$ and *Ox* axis;

*Mx* – point *M* projection to *Ox* axis.

Let us determine the *M* point coordinates via *w* parameter.

From the triangle $OM_xM_\pi$:

$$\frac{OM_x}{OM_\pi} = \cos w; \qquad OM_x = a\cos w. \qquad (6)$$

From the triangle $M_xMM_\pi$:

$$\frac{M_xM_\pi}{M_xM} = \cos\nu; \qquad M_xM = \frac{M_xM_\pi}{\cos\nu}. \qquad (7)$$

From the triangle $M_xOM_\pi$:

$$\frac{M_xM_\pi}{OM_\pi} = \sin w; \qquad M_xM_\pi = a\sin w. \qquad (8)$$

Substitute (8) into (7):

$$M_xM = \frac{a\sin w}{\cos\nu}. \qquad (9)$$

In (9) take notation

$$\frac{a}{\cos\nu} = b; \qquad M_xM = b\sin w. \qquad (10)$$

From (6) and (10) with due regard to (5) we obtain:

$$x = a\cos w;$$
$$y = b\sin w. \qquad (11)$$

So, we have obtained parametric equation of ellipse. Therefore, the line $l'$ constitutes the ellipse, as was to be proved. Minor axis of ellipse is equal to $a$, and major axis is equal to *b*; and it is protruded in direction of axis *y*.

## Conclusions and proposals for production.

To obtain the regular outflow of the mineral fertilizer pellets and other granulized materials over the surface of spreader cone of experimental colter in direction transverse to the travel speed its elliptical cross-section is required. To this effect the section plane should be directed perpendicular to travel speed, cross over all cone generators at an angle between it and central axis of the latter other than $\pi/2$.

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