Optimization of the parameters of the pneumatic feed mechanism for precise clustered sowing

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Abstract. The article is devoted to the description of one of the ways to improve the mechanization of sowing, namely, precise sowing in a clustered way. It is analyzed that precise sowing provides a given placement of plants over the area and makes it possible increase productivity, to reduce labor costs for thinning plants, seed consumption and operating costs of the aggregates. Data are presented on the mechanization of sowing row crops in Uzbekistan, on the main advantages and disadvantages of the applied mechanical and pneumatic planters. It is noted that industrial pneumatic feed mechanisms do not meet the increased quality requirements for clustered sowing of cotton seeds in Uzbekistan and are one of the factors limiting the widespread introduction of intensive technology. An analysis is given of the need to develop a pneumatic feed mechanism for precise sowing of row crops in a clustered way for the soil and climatic conditions of Uzbekistan and the justification of its parameters. The data on the study of the technological process of sowing and the refinement of the parameters obtained in analytical calculations are presented. According to the results of experimental studies and tests, the correctness of the theoretical premises and the performance of the experimental feed mechanism were checked. The optimization of the main parameters and operating mode of the feed mechanism for precise sowing in a clustered way has been carried out. The data obtained in the experiments were processed using the PLANEXP program developed for the Personal Computer and regression equations were obtained that adequately describe the evaluation criteria. Therefore, to ensure maximum accuracy of sowing cotton seeds and perform the required quality of work at aggregate operating speeds of 1.66-2.24 m / s, the number of revolutions of the sowing disc should be 23.87-27.62 rpm, and the installation height of the feed mechanism should be within 9.02-9.24 cm. With these values of the factors, criterion Y_1, i.e. the number of seeds in the cluster is 3.03-3.28 pieces, criterion Y_2, i.e. the distance between the clusters is 14.00-15.57 cm, and criterion Y_3, i.e., the length of the clusters is in the range of 0.95-1.12 cm, which meets the agro technical requirements.

1 Introduction

In cotton growing, in order to obtain high yields of raw cotton and reduce labor costs, great importance is attached to the further improvement of technology and the mechanization of cotton sowing. The development of sowing methods is aimed at increasing the uniformity of the distribution of seeds and plants over the area of the field, which, other things being equal, certainly provides an increase in yield. However, the uniform distribution of seeds over the area does not always correspond to the uniform distribution of plants, which depends on a number of other factors: the quality of seeds and the conditions for their germination, the death of some plants from diseases and pests, etc. Nevertheless, most researchers associate the increase in the uniformity of the distribution of plants over the area and, accordingly, the yield with the uniform placement of seeds.

With the improvement of farming culture, which provides for the creation of conditions for high field germination of seeds and the normal development of plants, including the use of effective methods of their protection, the uniform distribution of plants along the row is determined by the following main factors: soil and climatic conditions, the design and operation of the sowing feed mechanism, quality seed material, crop cultivation technology. One of the ways to improve the mechanization of sowing is the introduction of precision sowing, which has a number of advantages over conventional sowing. Precise sowing provides a given distribution of plants over the area. With precise sowing, a given placement of plants over the area and full-fledged seedlings are ensured with a low consumption of seed, which makes it possible to reduce labor costs for thinning plants and operating costs of the aggregates. It should be noted that thinning is the most important agricultural technique, because any delay in thinning leads to stunted growth, lag in plant development and crop maturation [1].

1.1 Precise sowing of cotton

Precise sowing or sowing cotton with a given number of seeds in a cluster, began to be used quite a long time ago, but until recently this method has not been widely used,

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due to the imperfection of precision sowing feed mechanisms and the low quality of seed preparation. Until recently, SCHX-4A and STX-4 seeders with mechanical sowing feed mechanisms were widely used in the cotton-sowing zone, in which the selection of a given number of seeds per cluster is carried out by cellular disks. The advantage of these devices is the possibility of sowing seeds of various industrial crops. Changing the sowing and clustering discs and changing the speed of the drive shaft allow to adjust the spacing and the number of seeds in the cluster. It should be noted that these seeders are obsolete, and their sowing feed mechanisms have a number of shortcomings. The cells of the sowing discs are very sensitive to the dimensional characteristics of the seeds, which makes it necessary to carefully calibrate the seed, in which about 15% of the seeds suitable for sowing go to waste [2]. Mechanical sowing feed mechanisms have a bulky set of sowing discs for each fraction of the seed.

For sowing tilled crops in Uzbekistan, seeders are used, the dosing device of which is disk vacuum-type sowing machines with a horizontal or inclined axis of rotation. Vertical-disc sowing feed mechanisms with a horizontal axis of rotation are installed on many foreign-made pneumatic planters. The most common models of this type are the planters Schmotzer (Germany), Sönmezler and Daichi (Turkiye), Case1200, New Holland (USA), Gaspardo (Italy) and others [3]. They gained popularity for the simplicity of the design solution providing a low seed drop height of up to 30-40 mm with the opposite direction of seed ejection in relation to the direction of movement of the planter. Pneumatic seeders imported from abroad in many respects meet the basic requirements for the quality of dotted sowing of loose seeds. However, during the operation of planters, there is an increased clogging of the suction holes with seed, as well as a low quality of single selection as a result of insufficiently reliable separation of “extra” seeds, which is one of the reasons for the disruption of the technological process and the stability of single-grain seeding. During the operation of these planters, seed crushing reaches 5%, and the ejection speed is up to 0.3 m/s, which is much less than the speed of the sowing aggregate [4]. The quality indicators of seed distribution during sowing are significantly lower than other similar seeders (the coefficient of variation in seed distribution in a row is about 45% at an aggregate speed of 2 m/s and a seeding rate of up to 15 pcs/m). Because of this, the distribution of seeds in a row is transformed, and the uneven placement of plants leads to a crop shortfall [5, 6]. The main disadvantage is that these planters do not provide precise seeding of cotton in the soil and climatic conditions of Uzbekistan. Industrial pneumatic sowing feed mechanisms do not meet the increased quality requirements for clustered sowing of cotton seeds and are one of the factors limiting the widespread introduction of intensive technology.

At present, clustered sowing with cotton seeds is used by 30-35% (in Uzbekistan). And exact sowing on 7 - 10% of the area occupied by cotton. The latter is explained mainly due to the shortcomings in the technology of preparing bare seeds and the lack of perfection of existing precision planters. The widespread introduction of precision seeding of cotton into production is an important national economic task, the solution of which is impossible without extensive scientific research aimed at improving agricultural technology, sowing technology, parameters of working bodies and mechanisms of planters. Previous studies in the field of technology and mechanization of cotton sowing are mostly experimental and cover only certain particular issues of this problem. The agrotechnical and technological requirements for the process of precision sowing and the quality of the work of the working bodies and mechanisms of the seeder have not been sufficiently clarified. There are not enough theoretical developments and generalizations that explain the regularities of the processes performed by the planter and allow to substantiate the optimal parameters and operating modes of the working bodies and outline the prospects for their further improvement.

The greatest effect of the clustered sowing method is provided when a given number of seeds are sown in the clusters, calculated to obtain the required number of plants, i.e. with precise sowing. Precise sowing is possible only when using bare calibrated seeds with good flow ability and uniformity in size. In this case, due to the higher uniformity of sowing, the consumption of seeds for sowing can be reduced by 2.5 - 3 times, and the labor costs for thinning seedlings can be reduced by about 3 times. Therefore, the development of a modern, energy-saving pneumatic sowing feed mechanism for precise sowing of row crops seeds in a clustered way for the soil and climatic conditions of Uzbekistan and the justification of its parameters require special studies.

The issue of placement of plants and cotton seeds in the cluster is not well understood. Literature data testify to the absence of influence on the cotton yield of the shape of the cluster (triangle, square, line) and indicate the need to remove plants from each other at a distance of 2 - 4 cm. It is noted that for better penetration of the soil layer by seedlings, it is desirable to place the seeds in the cluster closely. Taking into account the qualitative indicators of the technological process, we note that the number of seeds sown in the cluster should be determined based on the need to grow 2-3 plants in each cluster. Deviations from the given number of seeds in the cluster should not exceed ± 1 seed, and the number of such deviations is 10-15%. Placement of seed clusters during precision sowing should be carried out according to the following schemes: 1) square-nested sowing with row spacing of 60 cm and cluster spacing of 60; 50; 45 cm; 2) clustering with row spacing 60 cm and cluster spacing 40; 30; 25 cm and 3) clustering with row spacing 90 cm and cluster spacing 30; 25; 20 cm. Permissible deviations of the centers of clusters from the given value of the interval between clusters in case of frequent- clustering sowing should not exceed 20%. Calculations of plant density for plant placement schemes with the specified row spacing and cluster spacing show that these schemes fit well into the recommended plant density limits for soils of various fertility and water availability [8].

Table 1. Cotton clustering schemes on irrigated lands.

Plant placement scheme (row spacing x distance between clusters x number of plants in a cluster), cm x cm x pcs	Recommended limits of plant density, thousand pcs /ha
60x60x3	70-80
60x50x3	90-100
60x45x3	110-130
60x40x2	70-80
60x30x2	110-130
60x25x2	110-130
90x30x2	70-80
90x25x2	90-100
90x20x2	110-130

The purpose of designing sowing feed mechanisms is to ensure maximum uniformity of sowing seeds at minimum seeding rates. The result of the intended goal is saving seeds and obtaining early shoots with the required plant density, reducing labor costs and operating costs of the aggregates. Therefore, based on the analysis of the results of research and development work, it is necessary to choose the type and design of a pneumatic sowing feed mechanism that provides precise clustered sowing and determine the course of analytical and experimental studies aimed at substantiating the main parameters and modes of its operation.

1.2 Optimization of the main parameters and operating mode of the pneumatic sowing feed mechanism for precise clustered sowing of seeds

Agricultural machines and aggregates are complex and varied. Their work processes, as a rule, proceed under changing conditions and depend on a large number of interrelated variables, the analytical description of which is not always possible. Therefore, when studying such processes and solving a number of applied problems, methods of experiment planning are of particular importance, which compare favorably with traditional ones in that they allow you to simultaneously vary all the variables and, based on experimental data, build a mathematical model of the object under study, significantly improve accuracy, reduce costs, volume and time of conducting the experiment.

The task of the study is: by optimizing the parameters of the pneumatic sowing feed mechanism, to ensure the highest possible high-quality precise sowing of bare cotton seeds in a clustered way, which is the key to their early and uniform germination and good seedling development. Namely, carry out a study in order to expand the functionality of a pneumatic sowing feed mechanism for precise sowing a given number of seeds in a clustered way.

Before proceeding with the planning procedure for this task, some features of the operation of pneumatic planters for sowing row crops should be noted. The technological process of sowing seeds with pneumatic sowing feed mechanism can be generally divided into five stages. The first stage is characterized by the creation of a seed flow in bunkers (tanks for seeds), which ensures the maintenance of a constant optimum level of seeds in the suction zone. The second and most important stage is the capture (suction) of seeds and their removal from the layer. The third one - removal of excess seeds - is an accompanying one in the general technological process of sowing. The fourth and fifth stages include the transportation of seeds to the place of removal (dropping) of them from the suction holes and self-dropping. From the above diagram of the sowing process, it can be seen that all its stages are closely interconnected and ultimately determine the quantitative and qualitative uniformity of seed supply to the seed tube or directly to the furrow opened by the coulter.

We considered the second stage of the process, which was the subject of research by many authors and covered in a number of published works [9-11]. Most of them contain analytical dependences for determining the required vacuum in vacuum chambers, which ensures reliable seed capture, and the results of experiments. However, it should be noted that many authors of these works, considering this stage of the sowing process, made some assumptions and did not take into account the complex movement at the time of seed capture by suction holes, as a result of which they obtained approximate dependencies. In addition, some works are of a private nature, which also limits their scope, especially for the analysis of structures developed recently.

Using the prerequisites and assumptions made when considering the process of seed suction, we determine the required rarefaction in the vacuum chamber of the disk feed mechanisms, which ensures the reliable capture of seeds by suction cells with different parameters. It follows from the analysis of studies that, other things being equal, disk feed mechanisms require the least rarefaction, the suction process of which is accompanied by the creation of a movement of seeds associated with the disk at a speed approximately equal to the circumferential velocity of the suction holes. However, the specific features of the operation of the latest models of disc feed mechanisms and the make of intake seed chambers do not allow full use of this possibility of reducing the required vacuum [12].

Cell type selection. Disc sowing feed mechanisms can have two basic types of cells: a cell designed to be filled with a group of seeds intended for sowing in one cluster, and a cell designed to be filled with a single seed (single seed). In the latter case, the number of seeds required for sowing in one cluster is sown from the corresponding number (group) of one-seeded cells.

2 Material and method

The work was carried out on the basis of the Scientific Research Institute of Agricultural Mechanization of the Republic of Uzbekistan (SRIAM) in accordance with the priority direction of the development of science and technology of the republic II “Energetics, Energy and Resource Saving”, in accordance with the research plan of the SRIAM QXA-3-001 “Development of an energy-saving pneumatic planter for precision sowing of crop seeds” (2017-2018).

The influence of various factors on filling the cells of the sowing feed mechanism was studied on a special stand. The stand consisted of a frame, an electric motor, a V-belt, chain and gear bevel gears, a coulter section of a planter with a sowing feed mechanism and an endless web (tape). The rotation speed of the sowing feed mechanisms shaft was changed by changing the pulleys and transmission sprockets. A sticky layer was applied to the web to fix the sown seeds. In each experiment, at least 500 clusters were sown, in which the number of sown seeds was determined. According to these data, the distribution of seeds in clusters was calculated (in percent). This indicator most accurately reflected the accuracy of sowing seeds by the sowing feed mechanisms. The experiments were carried out in relation to the scheme of clustered sowing at a seeding rate of 3 seeds per cluster. The desired speed of the conveyor belt varied within the limits corresponding to the speed of aggregate (1.95 m·s-1, 2.22 m·s-1, 2.49 m·s-1, 2.76 m·s-1). The aggregate operating speed was 1.45 m / s (5.2 km / h) and 2.1 m / s (7.57 km / h).

The experimental pneumatic sowing feed mechanism performs precise sowing of bare cotton seeds in a clustered way, at operating speeds of the aggregate of 7.3 and 8.3 km/h, provides a distance between the clusters of 13.2 and 14.6 cm, 2.9 and 2.7 seeds in each cluster, the width of the clusters is 0.76 and 0.70 cm, respectively. The schemes of the pneumatic sowing feed mechanism and seeding disc are shown in Fig.1 and Fig.2.

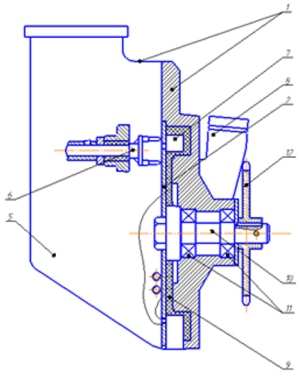


Fig.1 The scheme of pneumatic sowing feed mechanism.

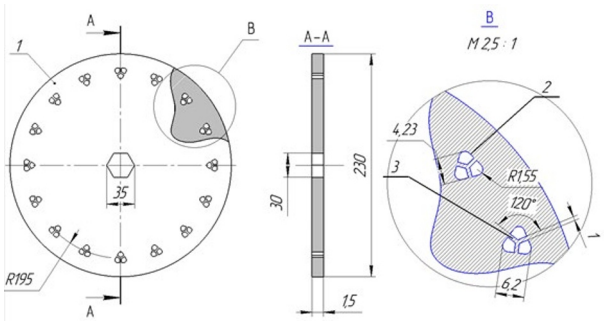


Fig. 2. Diagram of an improved seeding disc.

The changes made to the design of the sowing feed mechanism were as follows: the use of disks with two holes (option 1), three holes (option 2), cells made in the form of a triangle with rounded vertices and with a Y-shaped jumper inside (option 3). In the experiments, seeds of mechanical exposure of the cotton variety S-6524 were used, calibrated in length within the range of 9.2-9.65 mm, in width - 4.7-5.45 mm and in thickness - 4.2-4.73 mm. Residual hairiness of seeds 0.11%, weight of 1000 seeds 112.6 g, moisture content 8.05%. The technological process of sowing was studied and the parameters obtained in analytical calculations were refined. Experimental field studies were carried out in various soil and climatic conditions.

According to the results of experimental studies and tests, the correctness of the theoretical premises and the performance of the experimental pneumatic sowing feed mechanism were checked. The study used the basic laws of theoretical mechanics, higher mathematics, the laws and rules of mathematical statistics, methods of mathematical planning of experiments, strain gauge methods, as well as methods given in existing regulatory documents [13, 14]. To determine the optimal parameters and evaluate the agro technical and energy performance of the sowing feed mechanism, the following indicators were considered: the number of seeds in the cluster (pcs.), the distance between the clusters (cm), the length of the cluster (cm).

3 Results and discussion

The quality of the planter is usually characterized by the following indicators, such as the accuracy of sowing, the uniformity of the depth of placement and distribution of seeds on the soil surface, ensuring the seeding rate, minimum damage to seeds. These indicators depend not only on the design of the machine (the type of sowing feed and closing working bodies, the hitch scheme and the number of sowing sections, the capacity of the bunkers, etc.), but also on the geometric and kinematic parameters of its technological process. Thus, the planter is a multi-response and multi-factorial object of study. Therefore, a comprehensive study of it is a difficult task. The task of optimizing the seeder is also difficult. The complexity of the optimization problem is also determined by the high cost, laboriousness of manufacturing an experimental model of the machine, and the short duration of the season of its operation. All this ultimately leads to the fact that it is impossible to solve such a problem by setting up a one-stage experiment.

In such situations, a complex task is usually reduced to a sequence of simpler tasks. In particular, the problem we are considering is part of the global task of optimizing the sowing machine. It aims to expand the functionality of the main working body of the planter, namely the pneumatic sowing feed mechanism to ensure precise sowing of a given number of bare cotton seeds in a clustered way. At the same time, it is assumed that the previously achieved levels for its other indicators satisfy (or so far satisfy) agrotechnical requirements. Such indicators include, for example, the uniformity of the sowing depth and the degree of seed damage. Then the original problem can be reformulated as follows: by optimizing the geometric and kinematic parameters of the sowing feed mechanism of the pneumatic planter, to achieve the highest possible high-quality precise sowing (optimization parameter) of bare cotton seeds in a clustered way, while the uniformity of the sowing depth

and the degree of damage to the seeds must satisfy agrotechnical requirements [14].

The most important conditions for the operation of the sowing feed mechanism are reliable rarefaction and the correspondence of the diameter of the disc cells to the size of the group of sown seeds. In order for each cell to securely capture the seed, the vacuum in the vacuum chamber, depending on the type of seed, should be from 2.5 to 6.0 kPa.

The technological process of the sowing feed mechanism is as follows. The air, passing through the branch pipe 8 to the planter exhauster from the feed chamber 5 through the cells 3 of the sowing disk 2, creates a vacuum in the rarefaction chamber 7. Circular gasket 9 contributes to a tight fit of the sowing disc to the rarefaction chamber in order to avoid loss of vacuum force. The sowing disc, rotating under the action of the shaft drive 10 and the chain drive 12, entrains the seeds with an air flow, which in groups (3 pieces each) stick to the cells 3 with jumpers 4, regardless of their mass and shape. As a result, the path for the passage of air is closed and thus a constant vacuum is maintained in the chamber 7. According to the rational form of the group arrangement of 3 seeds, the shape of the cells is a triangle. For reliable suction of a group of seeds due to the complete locking of the cells, the vertices of the triangle have a rounded shape. Y - shaped jumper 4 helps a group of seeds to securely fix in the cell, in addition, it excludes damage to the seeds and clogging of the rarefaction chamber 7. The disk 2, rotating, transports the seeds beyond the limits of the vacuum. Groups of seeds leave the vacuum zone in the lower part of the housing 1 and, under the action of gravity, exactly 3 pieces fall into the furrow formed by the coulter in the soil.

To determine the optimal parameters and operating mode of the pneumatic sowing feed mechanism for precise sowing of cotton seeds by the clustering method, a multifactorial experiment was carried out using the method of mathematical planning [15-17].

From preliminary studies it was found that the accuracy of sowing and the distance between the clusters in a row significantly depend on the number of revolutions of the disk, the installation height of the device and the operating speed of the aggregate. The task of the study was to vary the listed factors to find such conditions for the process of sowing seeds, which ensure maximum sowing accuracy and a given distance between clusters in a row. Based on the results of preliminary studies, the boundary values of the factors and the intervals for their variation were established, which are given in Table 2. Assuming that the process of sowing seeds can be sufficiently described by a second-order polynomial, the experiment was implemented according to the Hartley-3 plan with a half-replica in a randomized order, and the processing of its results and the calculation of the values of the polynomial coefficients were carried out on a Pentium-4 computer using the program “P1anex-2” [18]. In the overwhelming majority of cases, the experimenter strives to ensure that there are as few experiments as possible in the experiment. Therefore, he usually tends to choose an experimental design that is saturated or close to saturated. One of the closest to saturated plans are those proposed by Hartley [19].

The number of seeds in a cluster (Y1, pcs.), the distance between clusters (Y2, cm), and the length of clusters (Y3, cm) were taken as evaluation criteria in multivariate experiments.

Table 2. Levels of factors and intervals of their variation.

Factors	Module	Levels of factors				
		encoded symbol	change interval	Under (-1)	Basic (0)	Upper (+1)
Seeding disc speed	r/min	X_1	5	22	27	32
Sowing feed mechanism installation height	cm	X_2	2	8	10	12
Aggregate operating speed	m/s	X_3	0,29	1,66	1,95	2,24

In experiments, to assess the homogeneity of the variance, the Cochran test was used, to assess the value of the regression coefficients - the Student's test, to assess the adequacy of the regression models - the Fisher test were used.

Regression equations were obtained that adequately describe the evaluation criteria:

- number of seeds in the cluster (Y1, pieces):

$$Y_1=2,921-0,155X_1\ 0,117X_2+0,000X_3++0,117X_1^2+0,103X_3^2\ ; \quad (1)$$

- distance between clusters (Y_2, cm):

$$Y_2=15,362-0,842X_1+0,000X_2+0,993X_3\ 0,622X_1^2++0,413X_1X_3-0,520X_2^2-0,420X_3^2\ ; \quad (2)$$

- length of clusters (Y_3, cm):

$$Y_3=1,117+0,099X_2+0,052X_3+0,051X_1^2-0,036X_2X_3+0,0012X_3^2; \quad (3)$$

As can be seen from the above regression equations, all factors had a significant impact on the evaluation criteria. When determining the values of the parameters that ensure the quality of work at the required level, the regression equations (1) - (3) were solved jointly for speeds of 1.66-2.24 m/s using the Excel program "search for a solution" on the Pentium IV PC computer. To determine the optimal parameters and modes of operation of the pneumatic sowing feed mechanism, which provide the necessary (more than 85%) accuracy of sowing seeds and the minimum length of their cluster at given aggregate speeds, the equations were solved by the method of "penalty" functions.

When jointly solving the regression equations, the Y_1 criterion was adopted, i.e. the number of seeds in the cluster should be 3 ± 1, the Y_2 criterion, i.e. the distance between the clusters should be 14-16 cm, and the Y_3

criterion, i.e. the length clusters should be minimal. The results obtained are presented in Table 3.

Table 3. Rational parameter values.

X_3		X_1		X_2	
Encoded	Natural	Encoded	Natural	Encoded	Natural
-1	1,66	-0,6252	23,873	-0,97125	9,029
0	1,95	-0,0475	26,7622	-0,84236	9,16
1	2,24	0,1258	27,629	-0,7568	9,24

Therefore, to ensure maximum precise of sowing cotton seeds and perform the required quality of work at aggregate operating speeds of 1.66-2.24 m / s, the number of revolutions of the sowing disc should be 23.87-27.62 rpm, and the installation height of the sowing feed mechanism should be within 9.02-9.24 cm. With these values of the factors, criterion Y_1, i.e. the number of seeds in the cluster is 3.03-3.28 pieces, criterion Y_2, i.e. the distance between the clusters is 14.00-15.57 cm, and criterion Y_3, i.e., the length of the clusters is in the range of 0.95-1.12 cm.

4 Conclusion

According to the results of studies of the physical and mechanical properties of the bare cotton seeds, according to the results of studies on the choice of types of pneumatic sowing feed mechanisms, it was revealed that:

•based on the analysis of studies of technical means used for sowing bare cotton seeds, it is possible to improve the technological process of the pneumatic sowing feed mechanism, justify its parameters, improve the quality and productivity of sowing seeds and reduce operating costs;

•according to the results of the study, it is recommended to use a sowing disc with suction cells made in the form of a triangle with rounded tops and with a Y-shaped jumper inside. A seeding disc of this design makes it possible to sow bare cotton seeds in a clustered way with high accuracy compared to other seeding discs;

•to ensure the required high-quality sowing of bare cotton seeds in a clustered way at a aggregate speed of 1.66-2.24 m/s, the number of revolutions of the sowing disc should be 23.8-27.6 r/min, the installation height of the sowing feed mechanism should be within 9.02-9.24 cm;

•the use of a pneumatic planter equipped with sowing feed mechanism with reasonable parameters will ensure precise sowing of bare cotton seeds in a clustered way. This will reduce labor costs by 8.5% and direct costs per 1 ha by 2.6%, compared with existing technical means, which will provide an annual economic effect of 10,104,783.2 soums per planter.

References

1. QXA-3-001 “Ekinlar urug‘larini aniq me’yorlarda ekadigan energoresurstejamkor pnevmatik seyalkani ishlab chiqish” amaliy loyiha xisoboti. – Gulbahor, p. 97 (2018)
2. P.K. Yushin. Obosnovanie parametrov pnevmaticheskogo visevayuщego apparata dlya tochnogo gnezdovogo seva xlopchatnika: Avtoref.dis.kand.texn.nauk. –Yangiyul, p. 18, (1984)
3. F.A. Alimova, M.T. Saidova. Pnevmatik ekish apparatining ilmiy tadqiqot ishlari uchun takomillashtirilgan laboratoriya stendi// Fan va texnika taraqqiyotida intellektual yoshlarning o‘rni: Res-publika ilmiy-texnikaviy anjumani tezislar to‘plami. – Toshkent: ToshDTU, pp. 221-222 (2021)
4. F.A. Alimova, A. Bayat. M.T. Saidova, B. Primqulov, M. Atadjanova. Solid State Technology, **63**, 6, 11876-11885 (2020)
5. A. Ye. Tolibaev. Obosnovanie parametrov i rejimov raboты pnevmaticheskogo vыsevayuщego apparata seyalki dlya tochnogo seva semyan soi: Avtoref. dis. ...kand.texn.nauk. – Yangiyul, 18 p. (2010)
6. F.A. Alimova, B.Sh. Primkulov. Features of the choice of working bodies for the technology ofstrip tillage when sowing re-crops AEGIS-2022IOP Conf. Series: Earth and Environmental Science 1076 012001IOP Publishing (2022)
7. N.P. Lobachevskaya. Sovershenstvovanie protsessa vыseva semyan klewevini apparatom pnevmaticheskoy seyalki: dissertatsiya kandidata texnicheskix nauk / N.P. Lobachevskaya. – Zernograd, 147 (2001)
8. G.M. Rudakov. Texnologicheskie osnova mexanizmi seva xlopchatnika. –Toshkent: Fan–pp. 284 (1974)
9. A. Yu. Nesmiyan. Teoriya raboti visevayushego apparata propashnoy seyalki vakuumnogo tipa / A.Yu. Nesmiyan, V.V. Doljikov, A.V. Yakoves// Vestnik Belgorodskogo GTU im. V.G. Shuxova. – 2, pp. 72–75 (1974)
10. P.Ya. Lobachevskiy, A.Yu. Nesmiyan, V.I. Xijnyak, A.S. Reuskiy. Povышenie kachestva zaxvata semyan doziruyuщimi elementami pnevmaticheskogo vыsevayuщego apparata, Sovershenstvovanie texnologiy i sredstv mexanizatsii polevodstva // Mejvuzovskiy sbornik nauchnыx trudov
11. A.V. Yakoves. Uluchshenie ravnomernosti raspredeleniya semyan propashnыx kultur / A.V. Yakoves, V.V. Shumakov // Agrarnaya nauka YevroSevero-Vostoka, 26, 46–50 (2011)
12. A.V. Yakoves. Povishenie tochnosti dozirovaniya semyan propashnix kultur pnevmovakuumnim vыsevayuщim apparatom: dissertasiya kandidata

texnicheskix nauk / A.V. Yakoves. – Zernograd, pp. 132 (2012)

13. A.Ю. Nesmiян, V.V. Doljikov, V.A. Radchenko // Sovershenstvovanie texnicheskix sredstv v rastenievodstve. – Zernograd: FGOU VPO AChGAA,107–108 (2010)
14. GOST 31345-2017 Texnika selskoxozяystvennaя. Seяlki traktornie. Metodi ispitani, Moskva: Standartinform, pp. 53 (2018)
15. O‘zDSt 3193. Qishloq xo‘jalik texnikasini sinash. Mashinalarni эnergetik baholash usuli. – Tashkent ,pp. 21 (2017)
16. Ю.V. Granovskiy, Osnovi planirovaniя ekstremalnogo эksperimenta dlya optimizasii mnogofaktornыx texnologicheskix prosessov / Ю.V. Granovskiy. – Moskva: Izd-vo Moskovskogo instituta narodnogo xozyaystva im. G.V. Plexanova, pp.120 (1971)
17. S.V. Melnikov. Planirovanie eksperimenta v issledovaniyax selskoxozяystvennix prosessov / S.V. Melnikov. – Leningrad: Kolos, pp. 198 (1972)
18. M. Augambaev, A.V. Ivanov, Ю.I. Terexov Osnovi planirovaniя nauchno-issledovatelskogo eksperimenta. –Tashkent: Ukituvchi, pp. 336 (1993)
19. H. Hartley. Biometrics, 15, 611-614 (1989)