Agrotechnical and Agrochemical Studies of Gas-Dynamic Effects on Soil and Plants

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Abstract: In this article, the issues discussed in the basis of the developed method for loosening the arable soil surface by micro-explosions are based on the principle of impact on the soil by a shock wave formed as a result of the detonation of fuel-air mixtures in the pipes of a gas-dynamic generator. In this case, the shock wave creates pulse pressure on the soil surface with a high gradient of increase. In this case, the plants are not damaged, since mechanical contact of the tool with the soil is completely eliminated. It has been established that soil treatment with shock waves leads to an increase in the total microbial number in the soil layer (D-30cm). After a day, continuous growth of small colonies of microorganisms is observed. Further observations of the development of the plant showed that at each phase (appearance of sympodial branches, beginning of flowering, etc.) cotton treated with shock waves is ahead of cotton in control plots in terms of phase timing. By the time of ripening, this lead reaches 10÷12 days. As is known, when the soil is sufficiently enriched with carbonic acid (H_2CO_3), soil stratification occurs, and at the same time the plants absorb the necessary elements well and develop better. The soil will contain a concentration of calcium, which displaces hydrogen, and in the final state, the nitric acid formed during the nitrification process will be neutralized. This is confirmed by the results of experimental studies, which showed the rapid sprouting development of cotton. Earlier ripening provides significant advantages in cotton growing - there is more time left for harvesting, the quality of the delivered fiber increases, and the risk of crop loss is reduced. Experts consider this property of the developed soil crust loosener GDRP (gas-dynamic soil loosener) to be very important.

1 INTRODUCTION

Currently, mechanical tillage throughout the world is carried out using mechanical tools. The force on the soil is transmitted through any tool - a harrow tooth, a plow share, a rotary sprocket needle, a disk, etc. and so on. It is obvious that science and technology do not have any serious alternatives to such a solution.

However, there are some types of soil cultivation in which the operation of mechanical tools is not perfect. For example, the task of loosening the soil crust in regions with a hot climate is solved by such methods as harrowing, “calcining” the crust with the tooth of a rotary hoe, manually with grape hoe and various prickly devices.

Mechanized methods of dealing with crust are not effective enough, because the tool, in contact with the crust, creates, in addition to forces directed normally to the surface of the crust, lateral shear forces. As a result, a shift in the crust elements occurs, “evering” and damage to the seeds. Because of this, it is problematic to increase the processing speed, and already sprouted fields cannot be processed at all, because Young plants are damaged (Tojiyev, 2019). Nevertheless, at present there are no effective solutions that replace mechanical tools. This once again demonstrates the difficulty of such a task. However, it is fair to say that the search must continue.

2 METHODS

This article outlines some of the results of such a search. The central idea of the research is to propose a detonation (explosive) wave as a “tool” of force.

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Detonation of gas mixtures of conventional combustibles (gasoline, gas) with air produces a force impulse with the following parameters:

a. pressure in the shock wave 35 atm;
b. flow rate of detonation products 800 m/sec;
c. movement of the detonation wave along the channel at a speed of about 1600 1800 m/sec.

Such a gas-dynamic impulse, hitting any surface, acts on it as a sharp, short blow. The impact force and direction can be adjusted and the impact can be directed, for example, strictly perpendicular to the surface without lateral (shear) force components. The “tool” is gas, as opposed to a harrow tooth, needle, etc. In this sense, the “explosive” effect promises certain advantages. But an explosion (even a micro-explosion) in agricultural technology is a completely new matter, unexplored by anyone, without printed information, raising many questions. Actually, the answers to these questions form the content of this article.

3 RESULTS AND DISCUSSION

The authors of the article are aware that within the framework of one study it is impossible to answer all the questions in such an unconventional matter, and therefore the main goal was not only to substantiate the proposed principle theoretically, in laboratory and bench conditions, but also to create prototypes of equipment and test them in natural conditions.

Note that the development of the GDR is not the scientific goal of this article, and the GDR scheme is used here; it is described to preserve the logic of presentation of all the material in the article and at the same time, details are omitted for the presentation of which would require a lot of space.

In general, the concept of a gas-dynamic soil ripper (GSD) is constructed as follows: an air source (compressor) is connected to the power take-off shaft (PTO) of the base tractor. The rotating compressor supplies air to the mixing chamber with fuel. The fuel is also supplied to the mixing chamber in strict accordance with the pressure H (air pressure in the fuel supply tank and the selected area f of the fuel nozzle. After the mixing chamber, the mixture enters the detonation wave generator, where it is periodically burned in detonation mode with a given frequency (Tojiyev, Erkaboyev, Rajabova, and Odilov, 2021). In Fig. 1. a schematic diagram of the gas flow control unit is given.

1-ignition chamber; 2-chamber check valve; 3-spark plug; 4-section; 5-turbulator; 6-acceleration pipe; 7-sensors; SI - system instigation; MPS – mixture preparation system.

In this regard, in 2020, we immediately conducted laboratory (without sowing in the field) experiments on the treatment of corn, cotton and dzhugar seeds with shock waves generated by the HDRP unit (Tojiyev and Rajabova, 2021).

Experiment scheme: 1) The seeds were placed in fabric bags, which were located on the ground between the output ends of the working bodies of the HDRP; 2) “irradiation” with shock waves from a working HDRP lasted from 1 to 3 minutes; 3) The development of sprouts was monitored and quantitative indicators were measured.

Observations were carried out on the dynamic growth of sprouts in Petri dishes and some parameters were measured. As follows from the information presented here, the development of sprouts of all three crops, the seeds of which were treated with shock waves, was accelerated. The size of the leaves and roots of these sprouts is significantly increased.

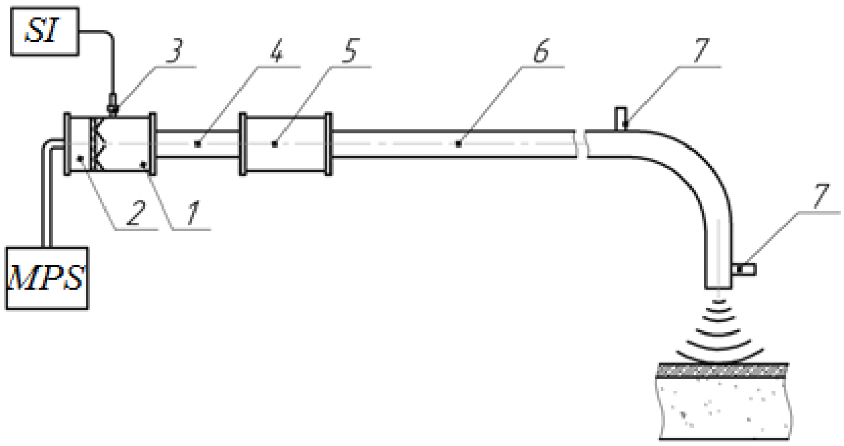

Figure 1: Schematic diagram of the gas flow control unit.

When a shock wave passes through the plant seeds, the latter experience short-term compression. The time of such compression is estimated at approximately 1/150000 sec (Tojiyev, 1993). Thus, the observed trend of accelerated development of seeds treated with shock waves served as an argument for launching a field experiment in 2020 in sowing seeds in the field.

For this purpose, the experimental plot was allocated with plots sown with cotton seeds pre-treated with shock waves.

Thus, laboratory and field experiments show that pre-sowing treatment of seeds with shock waves has a significant effect on their further development. Annual recording of the emergence of seedlings in experimental and control plots showed a stable trend in the emergence of cotton seedlings treated with HDRP during the period: after sowing and before emergence.

Table 1a: Dynamics of sprout development

Seed condition	Options	Germination %	Average length of the above-ground part of a sprout kov, cm	Average length of the above-ground part of a sprout kov, cm	Dynamics of sprout development	
					Average length of the root part of a sprout kow, in cm	Average length of the above-ground part of a sprout kow, in cm
		during 3 days			during 10 days	
White durra						
Dry	Control	90	2	2.5	4	6.5
	Processing t =30℃	100	4	2.7	6	6.8
	Processing t =60℃	100	2	1.9	7	7
	Processing t =120℃	100	6	2.5	6.5	8
Moisturized	Control	100	3	1.1	6	5
	Processing t =30℃	100	2.8	2.4	9	7.8
	Processing t =60℃	100	3.6	4.2	11	9.4
	Processing t =120℃	100	4.2	2.6	6	8.2
CORN						
Dry	Control	100	2.1	0.3	5.5	2.5
	Processing t =30℃	100	2.8	1.1	7	8
	Processing t =60℃	100	3	0.9	11	8
	Processing t =120℃	100	3	0.9	6.5	3.2
Moisturized	Control	100	4	1.06	5	5.5
	Processing t =30℃	100	6	1.2	6	5
	Processing t =60℃	100	6.5	2.2	6.5	6.5.
	Processing t =120℃	100	4.5	1.8	4.8	6.4

Table 1b: Date of Experiments Conducted from 08/18/2020 to 08/28/2020.

Seed condition	Options	Germination %	Average length of the above-ground part of a sprout kov, cm	Average length of the above-ground part of a sprout kov, cm	Dynamics of sprout development		Comment
					Average length of the root part of a sprout kow, in cm	Average length of the root part of a sprout kow, in cm	
		During 3 days			During 10 days		
1	2	3	4	5	6	7	8
White durra							
dry	Control	90	0.8	1.2	3.5	8	The stem is thick, the root is strong
	Processing t = 30℃	100	2	0.5	4.5	10	
	Processing t = 60℃	100	0.9	0.6	5	11.5	
	Processing t = 120℃	100	0.97	0.4	4	11	
moisturized	Control	100	0.9	1.3	3	8	The stem is thick, the root is strong
	Processing t = 30℃	100	2	0.9	6	10	
	Processing t = 60℃	100	1.5	1.1	4	12	
	Processing t = 120℃	100	2	0.8	5	12	
CORN							
dry	Control	100	0.5	0.45	4.5	4.6	
	Processing t = 30℃	100	3	0.97	5.5	7	
	Processing t = 60℃	100	2	0.6	11	8	The stem is thick, the root is strong
	Processing t = 120℃	100	1	0.68	11	4.5	
moisturized	Control	100	0.9	1.1	6	5	The stem is thick, the root is strong
	Processing t = 30℃	100	2	1.3	7	7	
	Processing t = 60℃	100	3	2.5	13.5	10	
	Processing t = 120℃	100	1.5	1.2	10	5	

Table 2: Emergence of seedlings as a percentage of the total number of seedlings

Experiment number according to the method	Emergence of seedlings as a percentage of the total number of seedlings					
	2 may	5 may	8 may	11 may	15 may	20 may
B1 (control section)	17,7 %	32,3 %	48,5 %	60 %	72,3 %	73,3 %
B2 (treatment with HDRP before emergence)	15,3 %	28,2 %	74 %	85,3 %	95,9 %	100 %

Table 3: Results of phenological observations at the end of the growing season

Processing options	Plant height, cm	Number of sympodia, pcs.	Number of boxes, pcs.
1	2	3	4
Zone 1			
B1	76	11,7	9,0
B2	75,4	11,3	10,1
B3	77,9	12,3	10,1
B4	76,4	11,4	10,0
B5	76,8	12,5	9,2
C_p	76,5	11,87	9,63
Zone 2			
B1	79,1	13,1	11,3
B2	75,3	13,4	12,8
B3	78,6	13,9	12,6
B4	74,6	13,7	12,3
B5	76,6	12,0	12,1
C_p	76,8	13,61	12,4
Zone 3			
B1	80,3	12,4	10,1
B2	80,6	13,7	12,8
B3	81,3	13,9	12,6
B4	79,9	12,4	12,5
B5	77,9	12,2	10,4
C_p	79,9	12,5	11,7

According to the above observations, not only the percentage of germination increases, but also, starting from a certain period, the process of germination of cotton treated with HDRP accelerates.

In the period following germination, cotton growth dynamics were observed. In the phase of several true leaves, the roots of the plants were washed (the plants were removed from the ground with the necessary amount of soil to preserve the root system and washed with water according to the accepted methodology).

Averaged data for a large number of samples show that the development of the root system in all experimental plots treated with HDRP before germination (B-2) and after germination (B-3) is significantly ahead of development compared to the control plot.

Examination of the root system of cotton after ripening (after harvest) gives the same results. Figure 10 shows a photograph of the roots of a mature cotton plant in comparison with a specimen from a control plot. Thus, the fact of enhanced development of the cotton root system in the case of impact on the soil and seeds by shock waves has been recorded (Tojiyev and Rajabova, 2021).

The results of further phenological observations (after germination) gave the following results (see Table 3÷7). From the analysis of experimental data (see Table 3÷7) it follows that the growth and development of cotton improves in all variants after treatment of crops with shock waves of HDRP. The best results are obtained by options B-2 and B-3 (treatment with HDRP before germination and after mass germination).

Taking into account the results of observations of the development of the cotton root system presented above, it can be argued that it is a more powerful root system that ultimately leads to such results.

However, closer attention should be paid to the fact that starting from germination and further throughout the entire period before ripening, there is a tendency to advance (accelerate) the development of cotton treated with shock waves.

Table 4: Weight of Raw Cotton Per Boll (g)

Processing options	Sympodial branch №3	Sympodial branch №6	Sympodial branch №9	Average weight	Increase in box weight relative to the control variant
1	2	3	4	5	6
Zone 1					
B1	5,13	5,60	5,40	5,40	-
B2	5,35	5,64	5,63	5,54	+0,14
B3	5,25	5,70	6,00	5,65	+0,25
B4	5,22	5,97	5,79	5,66	+0,26
B5	5,37	5,90	5,76	5,64	+0,24
C_p	5,22	5,74	5,79	5,59	+0,22
Zone 2					
B1	5,29	5,14	5,54	5,32	-
B2	5,62	5,60	5,55	5,59	+0,27
B3	5,33	5,81	6,09	5,74	+0,42
B4	5,29	5,64	5,89	5,60	+0,28
B5	5,32	5,71	5,67	5,57	+0,25
C_p	5,33	5,58	5,83	5,56	+0,3
Zone 3					
B1	5,43	5,75	5,31	5,49	-
B2	5,47	5,82	5,70	5,66	+0,17
B3	5,30	5,85	5,99	5,71	+0,22
B4	5,56	5,94	5,54	5,68	+0,19
B5	5,58	5,46	5,44	5,70	+0,21
C_p	5,47	5,80	5,54	5,65	+0,20

Table 5: Effect of HDRP treatment on cotton yield c/ha Section 1

Processing options	Repeatability of the experiment on the site			Avg. Yield a/y	Increase in yield, a/y
	I	II	III		
1	2	3	4	5	6
Control plot (without HDPR treatment), B1	29,9	30,0	28,3	29,2	-
Treatment with HDRP before emergence, B2	30,5	30,4	29,5	30,1	+0,9
Treatment with HDRP during mass shoots, B3	29,5	30,1	34,4	31,3	+2,1
Treatment with HDRP at the stage of 2-4 leaves, B4	29,2	28,9	32,7	30,3	+1,1
Treatment with HDRP after flowering, B5	30,3	30,2	31,5	30,6	+1,4
Average values	29,9	29,9	31,3	30,3	+1,4

Table 6: Effect of HDRP treatment on cotton yield c/ha (Section 2)

Processing options	Repeatability of the experiment on the site			Avg. Yield a/y	Increase in yield, a/y
	I	II	III		
1	2	3	4	5	6
Control plot (without HDPR treatment), B1	33,0	35,7	37,6	35,4	-
Treatment with HDRP before emergence, B2	38,4	37,2	35,9	37,2	+1,8
Treatment with HDRP during mass shoots, B3	32,5	34,5	43,2	36,7	+1,3
Treatment with HDRP at the stage of 2-4 leaves, B4	38,4	35,6	38,6	37,5	+2,1
Treatment with HDRP after flowering, B5	36,4	36,0	37,8	36,7	+1,3
Average values	35,7	35,8	38,6	36,7	+1,6

Table 7: Effect of HDRP treatment on cotton yield c/ha (Section 3)

Processing options	Repeatability of the experiment on the site			Avg. Yield a/y	Increase in yield, a/y
	I	II	III		
1	2	3	4	5	6
Control plot (without HDPR treatment), B1	37,3	33,8	34,9	35,3	-
Treatment with HDRP before emergence, B2	37,5	36,1	41,0	38,2	+2,9
Treatment with HDRP during mass shoots, B3	38,2	37,6	37,9	37,9	+2,6
Treatment with HDRP at the stage of 2-4 leaves, B4	41,3	32,1	35,3	36,2	+0,9
Treatment with HDRP after flowering, B5	38,9	34,3	33,9	35,7	+0,4
Average values	38,6	34,8	36,6	36,7	+1,7

To illustrate this fact, let us return once again to the analysis of germination. Germination data similar to those given in Table 2 are presented in the form of a graph in Fig.2. And according to the table. 2 and according to the graphical dependence in Fig. 2 it can be seen that, starting from some, the number increases, and the germination of seeds in the control (without HDRP treatment) areas begins to advance in time. At the germination stage, the advance in terms of timing reaches at least two thirds of days.

Further observations of plant development showed that at each phase (appearance of sigmoidal branches, beginning of flowering, etc.) cotton treated with shock waves is ahead of cotton in control plots in terms of phase timing. By the time of ripening, this advance reaches 10–12 days.

As is known, when the soil is sufficiently enriched with carbonic acid (H_2CO_3), soil stratification occurs, and at the same time, plants absorb the necessary elements well and develop better.

When treating the soil with a HDRP unit, the soil is enriched with carbon monoxide (CO2), and there is always a sufficient amount of moisture (H_2O) in the soil, which causes the reaction to occur.

$$CO_2+H_2O=H_2CO_3 \quad (1)$$

Research by Academician I.N. Antipov-Karataev and his colleagues show that calcium carbonate contained in the soil reacts according to the following scheme:

$$H_2CO_3+ H_2O+ CO_2=Ca(HCO_3)_2$$
$$Ca(HCO_3)_2+2H_2O=Ca(OH)_2+2H_2O+ 2CO_2$$
$$Ca(OH)+Ca_2+2OH \quad (2)$$

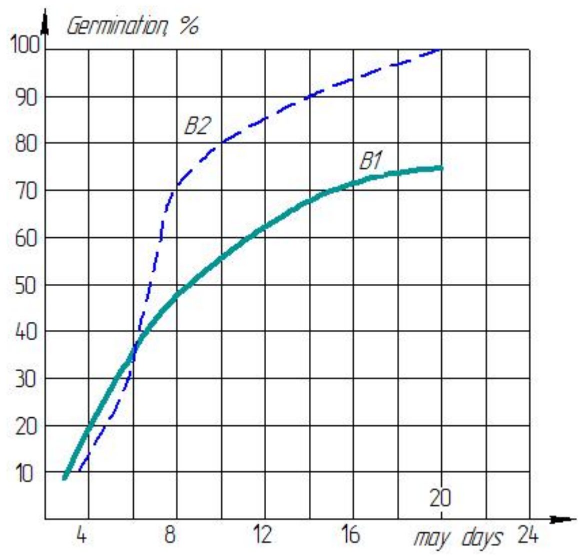

Figure 2: Germination of cotton when treated with HDRP before emergence. B1 – control; B2 – treatment with HDRP before germination.

Table 8: Determination of maturity, breaking load and metric number of cotton fiber in polarized light (cotton from the control plot without HDRP treatment).

Fields of view	Number of fibers by group				Total
	I	II	III	IУ	
I	29	10	3	1	43
II	25	12	2	-	39
III	27	14	2	-	43
IУ	28	12	3	1	44
У	23	8	5	2	38
УI	27	10	6	-	43
УII	25	8	4	1	38
УIII	27	9	6	1	43
Total	211	83	31	6	331
% %	63,7	25,1	9,4	1,8	100
Сорт	2	2	2	2	
Coef. Fortresses	5,2	2,7	1,6	04	
Work	331,2	67,8	15,0	072	41472
Coef.	130	80	55	40	
Work	8281	2008	317	72	10878
Coef. Fortresses	2,3	1,3	1,0	05	
Work	146,51	32,63	9,4	090	18944

Results: Coef. maturity 1.9
strength 4.1 gs
Metric number 163
Breaking length 25.1

The concentration of calcium ions in the soil increases, which displaces hydrogen, and the nitric acid formed during the nitrification process is ultimately neutralized. This is confirmed by the results of experimental studies, which showed rapid germination and development of cotton seedlings.

Earlier ripening provides significant advantages in cotton growing - there is a longer period for harvesting, the quality of the delivered fiber increases, and the risk of crop loss is reduced. Experts consider this property of the developed soil crust loosener (SCR) to be very important (Tojiyev and Rajabova, 2022).

Determining the maturity, breaking load and metric number of cotton fiber in polarized light (cotton from the area treated with HDRP) leads to rather unusual consequences (accelerated development of cotton at all stages), we checked the grown fiber in order to make sure there were no negative effects consequences of shock wave treatment. Tables 8 and 9 show the results of the analysis of the technological quality of cotton from the control plot and from the plot treated with HDRP.

Comparison of data from table. 8 and 9 gives grounds to assert that the properties of cotton fiber do not change from the processing of HDRP.

Table 9: Determination of maturity, breaking strength and metric number of cotton fibers in polarized light (cotton from areas treated with HDRP).

Fields of view	Number of fibers by group				Total
	I	II	III	IУ	
I	30	13	4	-	47
II	38	12	2	1	49
III	32	12	4	-	48
IУ	30	8	5	1	44
У	26	11	4	1	42
УI	21	10	5	2	38
УII	24	9	3	-	36
УIII	26	6	5	2	38
Total	22,2	80	33	7	342
% %	64,9	23,4	9,6	2,1	100٪
sort	2	2	2	2	
Coef. fortresses	5,2	2,7	1,6	04	
work	337,5	63,2	15,4	084	41694
Coef.	130	80	55	40	
work	8437	1872	528	84	10921
Coef. fortresses	2,3	1,3	1,0	05	
work	149,27	3042	9,6	1,0	19029

Results: Coef. maturity 1.9
strength 4.2 gs
Metric number 164
Breaking length 25.6

Experimentally, in laboratory and field conditions, an enhanced development of germination of cotton, jugara and corn seeds pre-treated with shock waves with an intensity of up to 35 atm and treatment times of up to 2 minutes was established.

4 CONCLUSION

The destruction of the soil crust in the period between sowing cotton and germination leads to an increase in the rate of mass germination of cotton by an average of 25% and to a decrease in the total period of one hundred percent germination by 2–3 days. The same effect is observed after shock wave treatment of crops in the absence of soil crust.

Two modes of treating crops with shock waves of HDRP, namely in the period before germination and after mass germination, lead to enhanced development of the cotton root system.

REFERENCES

GOST 3274.1-72 (ISO 1973-76, ISO 3060-74). Cotton fiber. Technical conditions.

Tojiyev, R. (1993). Mechanico-technological solutions for non-contact impact on soil and plants with the development of gas-detonation units for highly efficient cotton cultivation. Dissertation for the degree of Doctor of Technical Sciences, Ferghana.

Tojiyev, R. (2019). Application of the gas-dynamic principle in agricultural technology. Monograph, Ferghana, p. 140.

Tojiyev, R., Erkaboyev, X., Rajabova, N., & Odilov, D. (2021). Scientific Progress, 2(7), 694-698.

Tojiyev, R., & Rajabova, N. (2021). Scientific Progress, 2(8), 153-163.

Tojiyev, R., & Rajabova, R. N. (2021). Innovative Technological Methodical Research Journal.

Tojiyev, R. Zh., Mukhamadsodikov, K. Zh. (2020). Agrochemical and agrobiological studies of soil treated by a gas-dynamic method. Republican conference on solving theoretical and mechanical engineering issues, Ferghana.

Tojiyev, R. Zh., Mukhamadsodikov, K. Zh., & Sulaymonov, O. N. (2021). Scientific-technical journal FerPI, No. 2 (3), Ferghana, pp. 33-35.

Tojiyev, R. Zh., & Rajabova, N. H. (2021). Scientific-technical (STJ FerPI, FarPI ITZh, NTZh FerPI), 25, 6.

Tojiyev, R. Zh., & Rajabova, N. R. (2022). Scientific-technical journal (STJ FerPI, FarPI ITZh, NTZh FerPI), Vol. 26, No. 3.

Tojiyev, R. Zh., & Rajabova, N. R. (2022). Scientific-technical journal (STJ FerPI, FarPI ITZh, NTZh FerPI), 2023, 27, Special Issue No. 19.

Tojiyev, R. Zh., Sadullaev, K. M., & Isomidinov, A. S. (2021). Scientific-technical journal FerPI, 4, Ferghana.

Tojiyev, R. Zh., & Rajabova, R. N. (2022). Scientific-technical journal (STJ FerPI, FarPI ITZh, NTZh FerPI), Vol. 26, No. 3.

Tojiyev, R. Zh., & Rajabova, R. N. (2021). Scientific Progress, 2, 8, ISSN: 2181-1601.