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## Parameters Optimization for Multifunctional Aggregates in Plant Growing Mechanization.

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**ABSTRACT**

The article provides economic and mathematical models for some mechanized technological processes in plant growing to optimize multifunctional aggregates (MFA) parameters in the rational combination of technological operations for one MFA pass on the field. Besides its parameters operation time is optimized as well.
**Keywords:** optimization, multifunctional aggregates, plant growing mechanization, costs, operations combination.

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## INTRODUCTION

In connection with necessity of agrarian and industrial complex (AIC) products competitiveness increase agricultural mechanical engineering is challenged by the creation of equipment of new generation, radically modernizing technologies in crop production and reducing costs. Creation of each machine result from Machines System requirements of which are clearly formulated [1]. They pay attention to the formation of new type machine and tractor fleet (MTF), to the replacement of single-purpose machines by multifunctional machines, able to adapt to changing conditions of crop production through the rapid change of working tools. Multifunctional aggregates (MFA) realize simultaneously necessary operations in soil tillage, mineral fertilizers, seeds and pesticides introducing. All this will allow 2–2,5 times savings of fuel-lubricating materials, labor costs – up to three times, to ensure the growth of productivity by 30 percent [1]. In addition, it reduces the number of machines for the production of, for example, grains from 20–30 to 5–6 items, capital investments in mechanization being reduced 1,5–2 times [1].

It is difficult to overestimate the importance of these tasks and the high importance of expected impact, although they were set 10 years ago [1].

The purpose of our article is to show their efficiency in comparison with single-purpose machines by the example of basic types of multi-function aggregates (MFA) with the optimal parameters.

## MATERIALS AND METHODS

Mathematical model of multifunctional aggregates (MFA) parameters optimization includes variables, constants, constraints and objective function (optimization criterion). We have adopted cost and losses function as objective function. The notion of «cost and losses» function is not new in itself. It is a sum of costs, usually exploitation ones, for the implementation of mechanized operations, the MFA and the cost of product loss associated with the violation of the optimal duration of these works. Its use is known for example in harvesting aggregates [2, 3, 4]. The minimum value of the sum of costs and losses determines the optimal MFA parameters: width, required engine capacity, tractor and machine cost, and operation mode – speed.

To complete the task of high quality and low cost grain production it is necessary to observe the timing of harvesting, to improve the machines design, methods and organization of service. Along with harvesting in accordance with agro-requirements the whole complex of post-harvest laying the Foundation for future harvest must be respected in a single stream and rhythm. Unfortunately, this problem is solved with a gap in time between grain harvesting and the soil tillage, due to which 80-100 t/ha of moisture is lost each day [5] and future harvest. The farming system [5] provides immediate tillage after harvesting. However, in our view, this requirement is already obsolete, because only thorough cleaning in a single stream to perform basic operations of post-harvest complex is required [2]. But only MFA can perform such task.

Post-harvest soil tillage, planting catch crops, baling straw at present is done separately and requires additional expenditures of resources, energy and movement of heavy machinery on the field, leading to the thinning of the soil, its erosion, etc. In addition, scientific studies have shown high efficiency of green manure crop [6, 9] Thus, the yield of soybean when using oats as a green manure crop increased by 30 % on average over three years, the overall level of environmental pollution decreased, creating favorable preconditions for biologization of existing farming systems. In addition, green manure crops provide an effective background for spring planting of row crops on null processing [6]. And this work must be done by MFA.

For a multifunctional aggregate that performs grain crops harvesting with combine harvester TORUM-750 (plant Rostselmash, Russia) with the simultaneous pressing of straw with the attached to the harvester baler PRP-150 (Russia), the objective function $C_{зп}$ of costs and losses will have the following form after appropriate transformation (1):

$$C_{зп} = \left(\frac{248{,}04 + 0{,}0016 \cdot C_{Б}^{К} + 6{,}6 \cdot N_e + 0{,}00198 \cdot C_{Б}^{Пр}}{W} \cdot F^2 + z \cdot U \cdot F \cdot \frac{1{,}6 \cdot n - 2{,}5}{100}\right) \rightarrow min \qquad (1)$$

where $C_{Б}^{К}$ – the carrying value of a grain harvester, thousand rubles;

$N_e$ – combine engine capacity, kwt;
$F$ – the area of harvested crops, ha;
*z* – grain purchase price, rubles/t;
*U* – grain yielding capacity, t/ha;
*n* – harvesting duration, days;
1,6 and 2,5 – the empirical coefficients.

## RESULTS AND DISCUSSION

The block diagram of multi-function aggregate constructive and regime parameters optimization algorithm is presented in figure 1, and the objective function $C_{зп}$, which is the sum of $C_з$ costs to complete harvesting with simultaneous pressing of straw and the losses of $C_п$ harvest in connection with the increase of harvesting duration n, is implemented by an arithmetic operator 8.

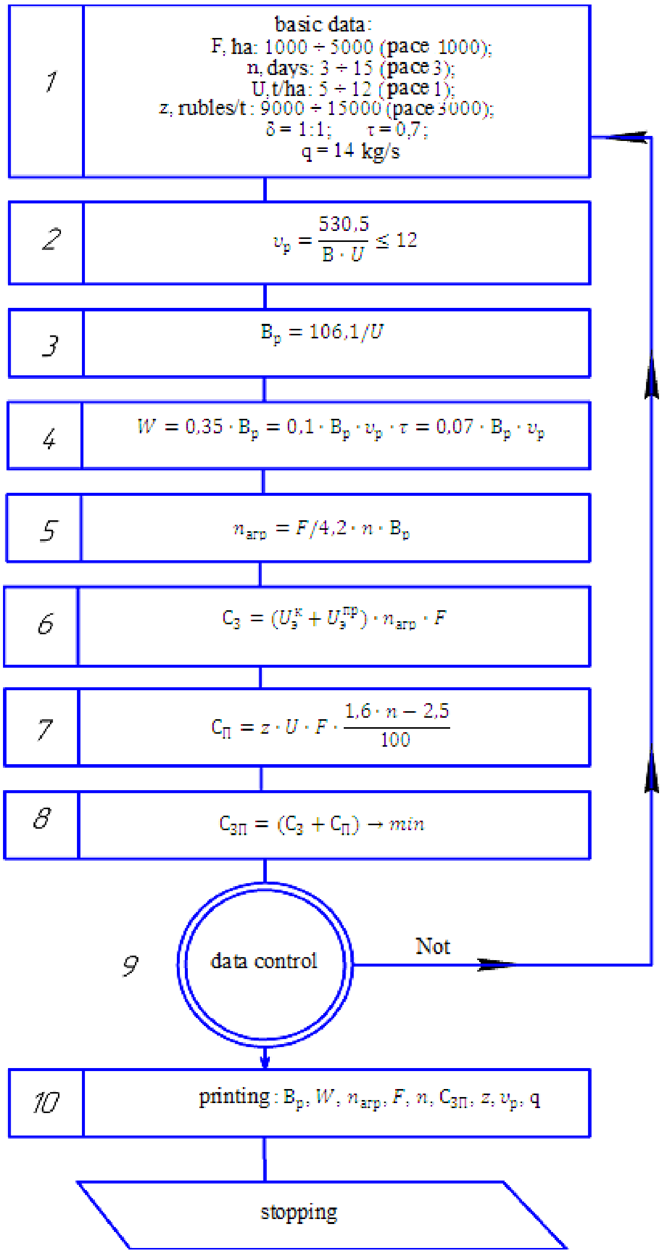


**Figure 1: The block diagram of four-wheel rotary combine harvester with simultaneous straw pressing parameters and operating modes optimization algorithm**

The minimum of the objective function $C_{3n}$ determines the optimal harvesting duration $n$ and the optimal aggregate parameters: width of $B_P$ reaper specified for grain yield $U$, the operating combine speed $\upsilon_p$, combine engine capacity $N_e$, its throughput (kg/s) and others. Thus, in MFA substantiation objective costs and losses function gives a reliable basis for objective decision making.

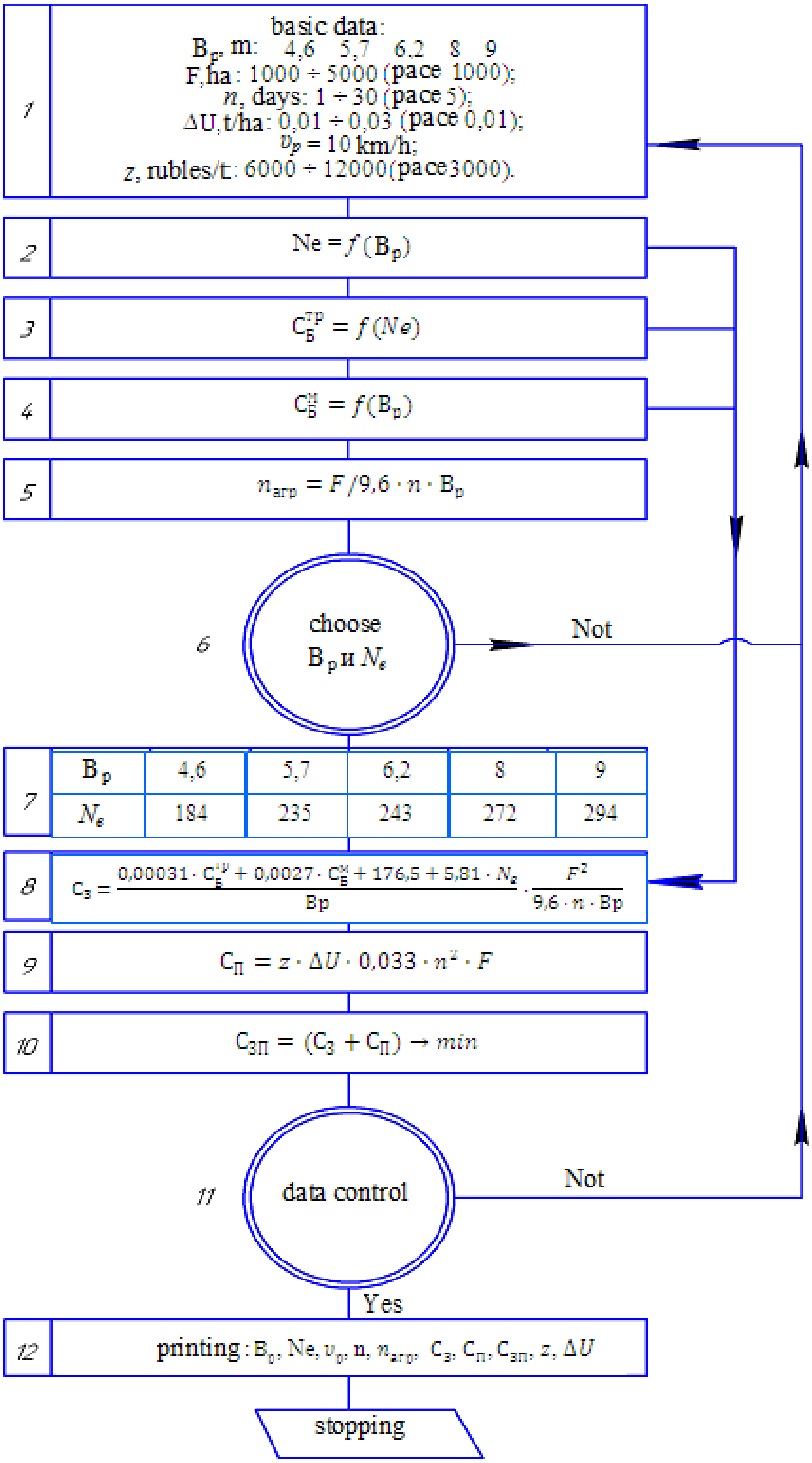


**Figure 2: Block diagram of MFA parameters and modes optimization algorithm for stubble tillage with simultaneous seeding of catch crops**

A similar problem of the harvesting aggregate parameters and operation modes substantiation with simultaneous straw pressing is solved by us for another part of MFA, in which vehicle UES-450 is used as a traction vehicle [2, 10] (Republic of Belarus), as a combine – mounted KZR-12 (Republic of Belarus), and the baler – PRP-150 as in the first task. As is known [2], the same costs and losses function is adopted as the objective function incurred by us including the cost of machines taken in part of MFA. The task solution allowed determination of reaper parameters ($B_p$ = 5,4 m),combine operating speed $\upsilon_p$ = 5 km/h the yielding capacity being U = 6,8 t/ha and optimal harvesting duration $n$ = 5 days [2].

Let us consider «costs and losses» function using on the example of the second MFA for stubble tillage with simultaneous seeding of green manure crop. Its technological scheme includes: frame, support wheels, disk working bodies, pointed feet, seeding device, bracket, spring harrows and press wheels.

This MFA fully loaded will allow agricultural consumers refuse separate acquisition of disc harrows, ploughs, cultivators that will provide reduced costs of purchasing new tillage equipment more than 2–3 times [7]. To optimize design and operating parameters of the above unit we have developed a mathematical model (Figure 2) in which the target function (the operator 10 of Figure 2) is presented by the cost and losses function of $C_{зп}$, seeking to a minimum.

The optimum of the objective function of the unit under consideration is a minimum of the costs sum of stubble tillage and losses of future corn grain harvest that will be planted on this site in the spring associated with the violation of the optimal length of stubble breaking.

As is known [5], the timing delay of stubble cultivation after cereal harvest for 2–3 days reduces crop yield the following year by 1.5–2 c per 1 ha. In this regard, the costs and losses function of $C_{зп}$ after transformation comes to (2):

$$C_{зп} = \left(\frac{0{,}00031 \cdot C_Б^Т + 0{,}0027 \cdot C_Б^М + 176{,}5 + 5{,}81 \cdot N_e}{B_p} \cdot \frac{F^2}{96 \cdot n \cdot B_p} + z \cdot \Delta U \cdot 0{,}033 \cdot n^2 \cdot F\right) \to min \quad (2)$$

where $C_{зп}$ – the amount of «costs and losses» for each day of stubble breaking with the MFA aggregate, thousand rubles;

$n$ – MFA aggregate operation duration, days;
$F$ – area of harvested crops, ha;
$C_Б^Т$ – tractor to the aggregate balance value, thousand rubles;
$C_Б^М$ – aggregate balance value, thousand rubles;
$\Delta U$ – grain yield losses per each day of optimal terms breaking, t/ha-day;
$B_p$ – working width, m;
$\upsilon_p$ – aggregate movement operating speed, km/h;
$\tau$ – time change utilization coefficient;
$z$ – corn grain purchasing price, rubles/t;
$n_{агр}$ – aggregates number, PCs;
$N_e$ – combine engine capacity, kwt.

In modeling the task according on minimum value of the objective function optimal duration $n$ of aggregate operation on stubble breaking is found with simultaneous seeding of green manure, the number of these aggregates $n_{агр}$, the optimal cost $C_з$ value for the execution of works and the optimal cost of the $C_п$ loss associated with the next harvest shortfall.

Aggregate optimum parameters are also found: width of $B_P$, the operating speed of $\upsilon_p$ movement and the tractor engine $N_e$ capacity for this unit.

The dependence of $C_{зп}$ and losses function is presented in Figure 3 and Table 1 presents the estimated value of all kinds of expenses, obtained according to the results of modeling of the combined Assembly (Figure 2).

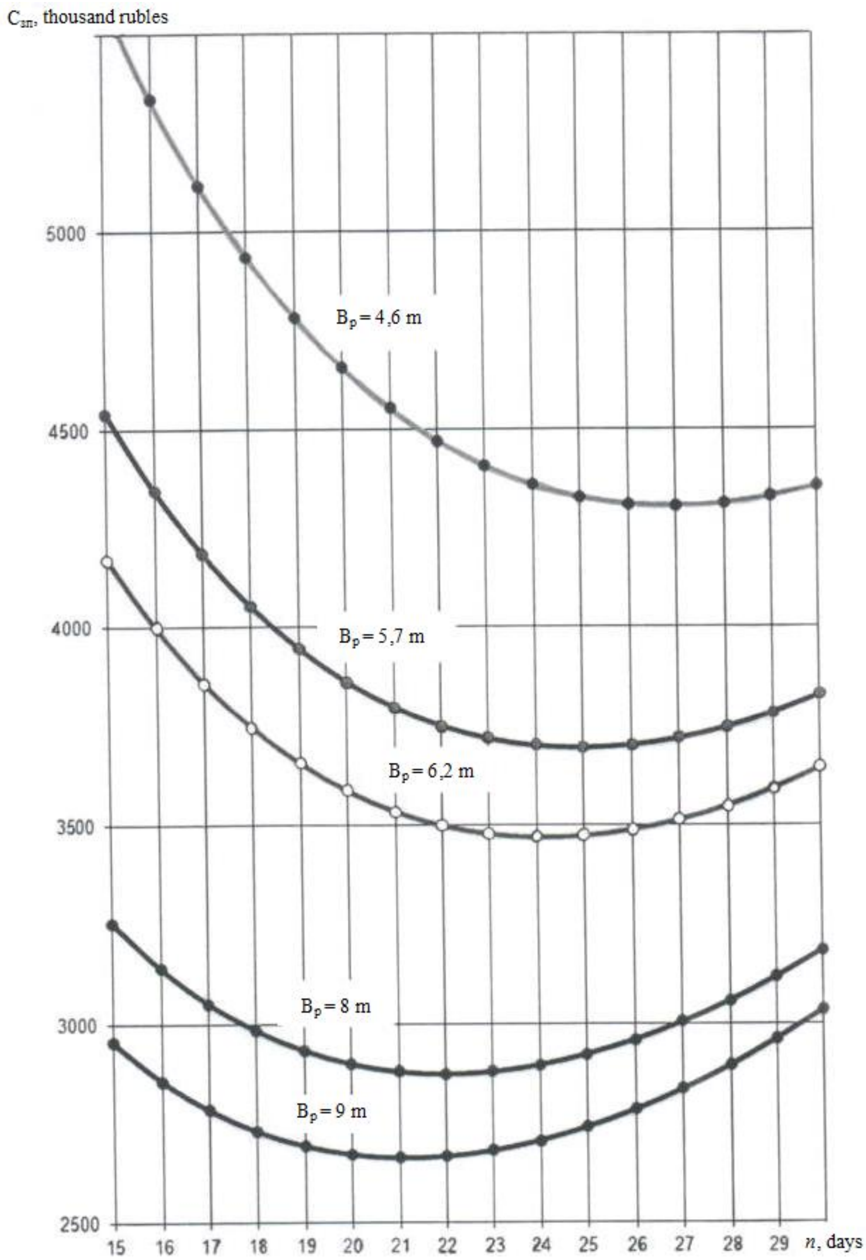


**Figure 3: The dependence of the costs and losses function of $C_{зп}$ on the works duration and execution**

**Table 1: Values of the $C_{зп}$ objective function in the modeling results for different aggregates compositions**

| Aggregate composition | | Minimum of $C_{зп}$ function, thousand rubles | Optimal duration of works *n*, days |
|---|---|---|---|
| Tractor engine capacity, kwt | Machine brand | | |
| 184 | VECTOR-460 | 4304 | 27 |
| 235 | VECTOR-570 | 3694 | 25 |
| 243 | VECTOR-620 | 3469 | 24 |
| 272 | VECTOR-800 | 2874 | 22 |
| 294 | VECTOR-900 | 2664 | 21 |

As follows from the Table 1, minimum costs and losses function $C_{зп}$ = 2664 thousand rubles is for aggregate VECTOR-900, to which the following optimal parameters correspond: optimal aggregate width $B_p$ = 9 m, working speed $\upsilon_p$ = 10 km/h, tractor engine capacity $N_e$ = 294 kwt, works execution cost $C_з$ = 1791 thousand rubles, losses cost $C_п$ = 873 thousand rubles.

In table 2 we have done the analysis of two compared technologies of crop stubble processing and sowing catch crops in the adopted area of 1000 hectares with the underlying technology and the perspective one – based on MFA with optimal parameters calculated via proposed mathematical models.

As follows from the analysis of Table 2, for basic and emerging technologies of stubble cultivation and sowing of mustard for green manure fertilizer high efficiency of the proposed technology is ensured through the use of MFA: the amount of agricultural works is reduced three times, the consumption of diesel fuel – 1.9 times (from 14.5 to 7.5 ton), labor costs to perform the entire scope of works – 9.4 times (from 1660 to 176.4 person-hours).

When performing agricultural work, according to Table 2, modern technique with effective technical and economic indicators is planned. Mechanization of separate processes for cultivation and harvesting of each crop with the application of MFA will form a highly efficient technological complex of machines [8].

**Table 2: The resources need for basic and advanced technologies of crop stubble cultivation and sowing intermediate crops on an area of 1000 ha**

| The font works | Agricultural works | Required resources to fulfill the entire scope of work | | | | |
|---|---|---|---|---|---|---|
| | | mechanizers | Machine and tractor aggregates | Motor hours | Diesel fuel, kg | Labour costs. |
| a) base technlogy | | | | | | |
| 1.1 | Mineral fertilizers transportation and introduction (0,15 t/ha) | 9 | 3 | 197 | 1700 | 212 |
| 1.2 | Stubble disking to a depth of 10–12 cm | 12 | 4 | 250,3 | 5700 | 270 |
| 1.3 | Pre-sowing cultivation to 3–4 cm | 6 | 3 | 152 | 2900 | 163 |
| 1.4 | Transportation of mustard seed for green manure (0.02 t/ha) | 2 | 1 | 1,3 | 4 | 1,4 |
| 1.5 | Seeds sowing (0,02 t/ha) | 7 | 4 | 217 | 2900 | 932 |
| 1.6 | Crops rolling | 4 | 2 | 77 | 1300 | 83 |
| a) perspective technology | | | | | | |
| 2.1 | Transportation of seeds and fertilizers to the unit (MFA) | 2 | 1 | 1,3 | 4 | 1,4 |
| 2.2 | Crop shallow plowing and sowing of mustard for green manure (0,17 t/ha) | 7 | 4 | 163 | 7500 | 175 |
| | | | | Total: | 7504 | 176,4 |

## CONCLUSION

The proposed economic and mathematical models of mechanized technological processes implementation with the use of multifunctional aggregates (MFA) allow optimizing these aggregates parameters according to the objective costs and losses function, the mode of their operation and the duration of its execution. Synthesis of scientifically substantiated MFA for the cultivation and harvesting of each crop is used to form high-performance technological complex of machines.

## REFERENCES


[1] Mikhalev A. A. On technological modernization of agricultural production in Russia / A. A. Mikhalev, A. A. Yezhevskiy, N. V.Krasnoshchekov // Technique and equipment for the village, 2005. – № 4.

[2] Maslov G. G. Prospects for integrated harvesting of crops: monograph / G. G.Maslov, A. V.Palapin, N. A.Rinas // Krasnodar: KubSAU, 2014. – 87 p.

[3] Truflyak E. V. Modern combine harvesters: textbook / E. V. Truflyak, E. I. Trubilin. – Krasnodar: KubSAU, 2013. – 320 p.
[4] Truflyak E. V. Corn harvesters: textbook / E. V. Truflyak – Krasnodar: KubSAU, 2008. – 249 p.
[5] System of Krasnodar Territory agriculture based on agrolandscape. – Krasnodar, 2015. – 352 p.
[6] Shelaikin S.V. Intermediate green manure crops and phytosanitary condition of the permanent barley sowings / S.V. Shelaikin [et al.] // Farming, 2005. – № 5. – P. 28–29.
[7] Multifunctional combined tillage machine // Food market and AIC technologies, 2015. – № 03(93). – P. 72.
[8] Maslov G. G. Rational Process Machines System for Producing Sunflower Seeds and its Effiliancy / G. G. Maslov, E. V. Trubilin // Worid Applied Seinces Journal, 2014. – № 29(12). – P. 1615–1620.
[9] Maslov G. G. The Improvement of The Technology of Winter Wheat Grain Production for The Purpose of Energy Saving / G. G. Maslov, V. T. Tkachenko, E. M. Yudina, M. R. Kadurov and S. A. Kalitko // Worid BLOSCIENCES BIOTECHNOLOGY RESEARCH ASIA. December 2015. Vol. 12 (3).
[10] Natal'ja Jur'evna Sarbatova, Vladimir Jur'evich Frolov, Olga Vladimirovna Sycheva and Ruslan Saferbegovich Omarov. Res J Pharm Biol Chem Sci 2016;7(2):534-538.
[11] Ivan Vyacheslavovich Atanov, Shaliko Zhorayevich Gabriyelyan, Irina Anatol'evna Bogolyubova, Lubov Fedorovna Maslova, and Maxim Alekseevich Mastepanenko. Res J Pharm Biol Chem Sci 2016;7(2):1409-1413.