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FORMATION OF SOYBEAN YIELD DEPENDING ON THE USE OF HERBICIDES

Abstract.
The combination of pre-emergence and post-emergence use of the studied drugs had a greater phytotoxic effect on the main weed species in soybean crops. Thus, cereal weeds were destroyed by 100%, Amaranthus retroflexus by 93%, and Chenopodium album by 94%. It should be noted in the areas where the composition was applied Frontier® Optima emulsion concentrate + Corum liquid concentrate + surfactant Metholate + Quantum - Molybdenum Chelate phytotoxic effect on weeds increased, and soybean plants later grew and developed better. Weed control rates for soybean weeds were 94-100% compared to control plots during the soybean harvest period. Yield of soybean seeds, where herbicides were applied in comparison with the control was on average: when using the herbicide Frontier®Optima e.c., 1,0 l/ha – 2,09 t/ha, Corum l.c., 1,5 l/ha + surfactant Metholate, 1,0 l/ha – in accordance 2,57 t/ha., and when applying Frontier® Optima e.c. + Corum l.c. + surfactant Metholate – 2,78 t/ha.

Keywords: *soybean, grains, weeds, herbicides, harvest.*

Formulation of the problem. Soybeans are a universal legume and oilseed crop. Growing soybeans in Europe produces an average of 3-4 tons of grains per hectare, while in Ukraine only 2 tons. Collectively, soybean is a strategic crop in solving the global food problem, is an extremely important source of vegetable protein and oil in the world, is the main protein ingredient in feed production, a powerful biological fixer of atmospheric nitrogen, a stabilizing factor in crop rotation. The main reason is the high weediness of the fields and the insufficiently. Therefore, the development of the most efficient, least economically and environmentally friendly weed control system using chemical plant protection products for growing soybeans in different farming systems is an extremely important element of innovative development in crop production.

Analysis of recent research and publications. Soybean production in the world is growing rapidly and reached 253 million tons, because it greatly affects the food security of civilization. Soybeans are grown in major agricultural regions in 90 countries. Its crops absorb 20 million tons of biological nitrogen, due to which the world economy receives more than 128 billion dollars a year. [4].

Analysis of statistical data conducted by Sendetsky V.M., indicates that in terms of soybean production, our country ranks first in Europe. Compared to 2016, in 2017 the harvest increased by 500 thousand tons - from 3.9 million tons to 4.3 million tons [16].

Under favorable weather conditions in 2018, the gross harvest of soybeans in Ukraine reached 4.3 million tons, which brought our country to 8th place among its world producers. However, the potential of the crop is much higher: in Europe, one hectare produces an average of 3-4 tons of grain, while in Ukraine only 2 tons. The main reason is high weediness and insufficiently effective protection of soybean crops [17].

Glycine max (L.) Merrill is the main legume in the world. It belongs to the strategic cultures and meets the most general needs of mankind [6].

A number of leading scientists Babych A.A., Babych-Poberezhna A.A. note in their works that soybeans have strongly entered the world agriculture and play a strategic role in solving the global food problem. Between 1961 and 2010, the world's soybean sowing area increased from 23.8 million hectares to 102 million hectares, it was grown by more than 90 countries in the main agricultural regions of the planet Earth, and the yield during this time increased from 11.28 to 25.5 c/hectares, production - from 26.9 million tons to 260.8 million tons [3].

In terms of intensity of biological nitrogen fixation, soybeans exceed other grain legumes. Characteristically, the average level of biological nitrogen fixation by legumes increased from 62 to 136 kg / ha, or 2.2 times. The variability of the intensity of biological nitrogen fixation among 12 main grain legumes was in the range of 48–183 kg / ha [3].

Soybean seeds contain 38-42% protein, 18-23% fat, 25-30% carbohydrates, including soluble sugars - 9-12% of seed weight, starch - 3-9%, fiber - 3-7%, about 2% phosphatides, 4- 7% of inorganic substances, microelements, enzymes and vitamins [15].

The main protein of soy - glycidin - is able to coagulate from fermentation, which allows you to make soybean seeds a large number of different foods. At the same time, medical science has established that foods made from soy contain antisclerotic substances, which is very important for the elderly [2].

The inclusion of soybeans in crop rotation and the use of bio-residues in the fertilizer system has a good effect on maintaining soil fertility. Soybean, as a legume, enriches the upper part of the root layer of the soil with well-digested forms of nitrogen, which makes it one of the best precursors [13].

Well-developed soybean crops biologically fix 155–198 kg / ha of nitrogen. Due to this, soybeans satisfy their need for nitrogen by 65–80% and are one of the best precursors in crop rotation [1].

Soybean, as a light-loving crop, forms a high yield only at the optimal for a particular variety of feeding area and density of plants, providing moisture and nutrients, but the main requirement - the best illumination of the leaf surface [19].

Soybeans remain weeded for 2-3 weeks from sowing to the appearance of the first trifoliate leaf. At this time, the future harvest is genetically laid down. If soy is not protected at this time, it genetically reduces the yield potential, and this process is irreversible. The most optimal period for weed control is the phase from the first to the third trifoliate leaf of the crop (this is the period from which soybeans are most "resistant" to action against dicotyledonous and cereal herbicides) [8].

At the beginning of the growing season, soybeans are quite competitive against weeds due to the significant reserves of plastic substances in the seeds and intensive growth. But later, the short length of the stem, slow growth in the initial period of development, low crop density (50-60 pieces / m^2) do not allow it to compete with weeds. Therefore, field litter is a significant obstacle to obtaining high and stable soybean yields. During the critical growing season on a weed background, soybeans significantly reduce their productivity. According to generalized long-term data, each quintal of raw mass of weeds causes a shortage of more than 13 kg of soybean seeds [18].

Shevchenko M.S., Shevchenko S.M., Derevenets-Shevchenko K.A., etc., in their work note that the decrease in gross harvest of crops due to weeds is 25-30%, in some cases exceeding 50 % [20].

By absorbing large amounts of nutrients from the soil, weeds impair the normal growth and development of cultivated plants. Due to the lack of appropriate measures to protect crops, weeds are able to absorb 160-200 kg / ha of nitrogen, 55-90 kg / ha of phosphorus and 170-250 kg / ha of potassium [16].

Weed populations are almost ubiquitous in the structure of agrophytocenoses, forming for each field its species composition and number of individual weed species, as well as the potential stock in the soil of their seeds and vegetative reproductive organs. The well-known Ukrainian herbologist Ivashchenko I.I. notes that modern weed populations have acquired a set of features that allow them to withstand intense anthropogenic impact, both mechanical and chemical [14].

The interaction between crops and weeds in soybean crops has its own characteristics. Soybean plants grow very slowly during the first growing season and have little effect on weed growth conditions, so rapid growth of segetal vegetation is observed. Root secretions enriched with nitrogen and other compounds improve the feeding conditions of weeds [7, 11].

Studies have shown that the linear application of new generation soil herbicides based on Harnes acetochlor from the American company Monsato and Trophy of the former British company ICC, and now Zeneca, was 81.5 and 76.1%, respectively, 1 l / ha on the impact on weed crops [5].

Various post-emergence herbicides can effectively control monocotyledonous and dicotyledonous weeds, but there are segetal and ruderal weeds on which post-emergence herbicides have little effect (about 30-40%). The need to use tank mixtures of herbicides with different mechanisms of action is due not only to the expansion of their spectrum of action, but also the ability to reduce the risk of resistance, ie the acquired resistance of weeds to certain chemical compounds. Tank mixtures of herbicides prevent the emergence of resistant weeds. This significantly increases the effectiveness of herbicides while reducing the financial costs of re-application [10].

BASF experts have found that in order to kill weeds in soybean crops, it is advisable to apply herbicides before they reach a certain stage of growth and development. By the time the triple-leaf phase in soybeans occurs, white quinoa can already have up to 6 leaves, on which a wax layer is formed, due to which the herbicides do not work. The effectiveness of application of post-emergence herbicides is significantly increased by the application of weed cotyledons, the use of their tank mixes and the addition of quality adhesives. Some post-emergence herbicides are able to show high activity and selectivity to the culture when applied to the emergence of culture seedlings. Thus, the herbicide "Fabian", applied as a soil, provided a significant reduction in weed crops and increase crop yields [9].

Thus, the intensive technology of soybean cultivation involves the use of chemical plant protection measures, which leads to an increase in pesticide loads on agrocenoses and the environment. To reduce the toxic effects of herbicides, reduce their consumption rates, it is necessary to use herbicide compositions and microfertilizers in soybean cultivation technology, but the main attention should be paid to proper crop rotations and scientifically sound tillage systems.

The aim of the research is to substantiate the feasibility of using soil and post-emergence herbicides to control weeds and foliar application of microfertilizers in soybean agrocenoses.

Research methods. Field - to monitor the growth and development of plants, environmental conditions, assess the agro-technical and economic effect of the studied elements of technology; measuring and weighing - to account for yield.

The research was conducted in the experimental field of VNAU the village of Agronomic. The soil at the experimental site is gray forest medium loam. According to the agrochemical survey, the humus content in the arable layer is low - 3%. The content of easily hydrolyzed nitrogen (according to Cornfield) is low - 7.0-8.0; mobile phosphorus (according to Chirikov) high -16.0-19.4; exchangeable potassium (according to Chirikov) increased - 9.5 mg / 100 g of soil.

Hydrolytic acidity is high and is 4.32 mg-eq./100 g of soil. In terms of metabolic acidity, pH 5.0-5.4 is a medium-acid soil. The soil of the experimental site and its agrochemical parameters are typical for this area and suitable for soybean cultivation. Vinnytsia district is located in the temperate zone. Maximum precipitation occurs in May - July (130-170 mm). The least humid

are the winter months. In December - February it falls from 65 to 80 mm. The average annual rainfall is 440-590 mm.

Soil preparation and tillage are generally accepted for the Forest-Steppe Zone of Ukraine, which provides for maximum weed control, accumulation of moisture and creation of favorable conditions for the growth and development of cultivated plants. After harvesting the predecessor (spring barley) stubble was peeled with disc harrows BDN-3A to a depth of 5-6 cm. In the spring cultivation was carried out to a depth of 4-5 cm. Three days before sowing, the soil herbicide Frontier® Optima (1.0 l/ha) was applied with simultaneous earning into the soil. Omega Vinnytsia soybean variety was sown. Before sowing, soybean seeds were treated with rhizotorphin (50 g per hectare sowing rate) and pesticide (Vitavax 200ff) at the rate of 3 l/t of seeds. Sowing was carried out in a narrow row with a row spacing of 15 cm seeder Klon. Harvesting of soybean seeds was carried out in the phase of full maturity, at its humidity of 14-15% by direct combining.

During the growing season of soybean plants, the following observations and records were made: phenological observations of the growth and development of soybean plants; assessment of the effect of herbicides on weeds, crop accounting - sheaf method and weighing from each site. Weed accounting was performed by quantitative-weight method. The essence of this method is to allocate on the plots of permanent accounting plots of a certain size [12].

During the growing season, the condition of plants in the herbicide-treated areas was monitored. Signs of their damage, terms and degree of manifestation of these signs, death of plants are noted.

The influence of herbicides on the emergence of crop seedlings, plant density, timing of growth and development phases, crop structure were determined. Harvest accounting was carried out at each plot separately, from the entire accounting area. The size of the accounting area is 20 m^2, repeated four times.

Mathematical processing of research data was performed on a personal computer with a set of programs such as "Sigma" and Exel.

Presenting main material. Our research has shown that soybean crops have formed a mixed type of weed, where dicotyledonous weed species predominate. Among cereals were present: mouse blue (Setaria glauca (L.) Pal. Beauv.), Chicken millet (Echinochloa cruss-galli (L.) Pal. Beauv.) (Table 1).

Table 1

Weed sctructure of soybean agrocenosis (average for 2019-2020), pcs / m^2

Cereal weeds					Dicotyledonous weeds								
Gramíneae	Setaria pumila	Echinochloa crus-galli	Avena fatua	Other	Dicotyledones	Chenopodium album	Amaranthus retroflexus	Thlaspi arvense	Persicaria hydropiper	Raphanus raphanistrum	Tripleurospermum inodorum	Cirsium arvense	Other
39	16	15	6	2	63	16	14	12	8	5	4	2	2
Total 102													

Crops are characterized by re-weeding in the second half of summer. The spread of quinoa, species of amaranth, chicken millet, yellow bristle-grass and other species reduces the productivity of the crop and complicates the process of harvesting, as well as increases crop losses.

Soybeans grow relatively slowly at the beginning of the growing season, and weeds compete with them for moisture, nutrients, and light. This makes it less competitive than weeds. Yield losses from weeds can range from 30 to 50%. The critical period for weed control is the phase of 1 to 3 true leaves of the crop.

Subject to treatment with herbicides with one active substance or mechanism of action, we obtain a larger number of resistant species that re-form seeds and have increased resistance. With long-term such use, there is a complete replacement of susceptible species with resistant ones.

From soil herbicides, we investigated the effect of the drug Frontier® Optima, which was applied to soybean crops at a rate of 1.0 l / ha. Studies have shown high herbicide and cost-effectiveness of the drug Frontier® Optima.Thirty days after application of the Frontier® Optima herbicide, there were only 11 pieces / m^2 of weed plants in soybean crops. Cereal weeds were completely absent, only stable dicotyledons remained, in particular quinoa, bitters. This amount of weed vegetation is 79% lower compared to the weed control version, where no herbicides were applied. The efficiency of destruction of annual dicotyledonous and cereal weeds 60 days after application of Frontier® Optima was 75% compared to the control. Before harvesting, the weediness of soybean crops increased slightly and was in the range of 26 pcs / m^2. This figure is 72% lower compared to weeds in the control version, where at the time of harvest there were 94 pieces / m^2 of weed plants. From the results of research it can be concluded that the application of soil herbicide Frontier® Optima reliably protects soybean crops during most of the growing season.

As the degree of contamination of the soybean agrophytocenosis was high, especially with dicotyledonous weeds, we decided to use the post-emergence

herbicide Corum pk, 1.5 l / ha + surfactant Metholate, 1.0 l / ha in addition to the soil herbicide Frontier® Optima.

The consumption rate of the working solution is 200-250 l / ha. Metholate is a drug that opens the entrance to the internal systems of quinoa, allowing the active components of the product Corum® to effectively destroy it. The metholate contains substances that reduce the surface tension of the working solution, allowing it to adhere firmly to the leaf. Another feature of Metolate is its ability to dissolve wax and facilitate the penetration of the active ingredients of the herbicide into the leaf. The combination of the special formulation Corum® with surfactant Metholate has a high buffering capacity, which allows you to keep the pH of the solution within optimal limits sufficient to dissolve cuticular waxes and penetrate into the tissues of the leaf.

Table 2

Influence of herbicides on weed infestation of soybean agrocenosis (average for 2019-2020)

A variant of the experiment	Technological type of herbicide	Accounting	Weed rates	
			Quantity, pcs / m^2	Reduction of % to control
Control (without processing)	--	1	102	--
		2	96	--
		3	94	--
Frontier® Optima coefficient., 1.0 l / ha	soil	1	21	79
		2	24	75
		3	26	72
Corum l.c.,1,5 l/ha + surfactant Metholate, 1,0 l/ha	insurance	1	102	-
		2	11	89
		3	7	93
Frontier® Optima e.c., 1,0 l/ha + Corum l.c.,1,5 l/ha +surfactant Metholate, 1,0 l/ha	soil + insurance	1	20	80
		2	3	97
		3	1	99
Frontier® Optima e.c., 1,0 l/ha +Corum l.c., 1,5 l/ha +surfactant Metholate, 1,0 l/ha +Quantum -Molybdenum Chelate (Mo), 0,5 l/ha	soil + insurance + microfertilizer	1	19	81
		2	2	98
		3	1	99

Due to the high selectivity and soft action, the Corum® application window is very wide - from one to five trifoliate leaves. But the main factor is not the phase of crop development, but the phase of weed development, and we should focus on the most problematic weeds. Dozens of studies across Europe have shown that even a double dose of Corum®, administered with or without Metholate, did not reduce yields. Keep in mind that imazamox, which is contained in the herbicide Corum®, is part of the Clearfield® system, the products of which should not be used more than once every three years.

According to prof. O.O. Ivashchenko, the sensitivity of white quince to the action of herbicides in the cotyledon phase reaches more than 99%, and in phase 4 pairs of true leaves only 38.5%. That is why the recommendations for the use of Corum® on soybean and pea crops should be divided into two parts [16]. The first is the culture in the early stages of development, the weeds are not overgrown (in the cotyledon phase - the first pair of true leaves). For such conditions the norm of Corum® 1,5 l / hectare + surfactant Metholate of 0,75 l / ha will be sufficient. The second - problem weeds, in particular quinoa, overgrow (3 pairs of leaves - the beginning of branching). In this case, the maximum rate of Corum® 2.0 l / ha + surfactant Metholate 1.0 l / ha should be applied.

Our studies showed that the herbicide Corum® 1.5 l / ha, which is used in the experiment, significantly reduced the weediness of soybean crops compared to growing without herbicides and manual weeding. Corum® herbicide 1.5 l / ha was applied to phase 5 of trifoliate soybean leaves (early phases of weed growth). After applying the herbicide for a week was dry cool weather. Weed accounting has shown that when the drug is applied to vegetative plants, its phytotoxicity depends to a lesser extent on the species composition of weeds. Accounting conducted 30 days after spraying the crops showed that the effectiveness of Corum® 1.5 l / ha against the weed complex in soybean crops was 89% compared to the original weed. This drug effectively destroyed cereal weeds (92-97%). The total number of weeds decreased at the time of harvest by 93% compared to baseline, which proves the high efficiency of the drug to eliminate weeds in soybean crops (Table 2).

The effectiveness of the combined use of soil and post-emergence drugs in our experiment was quite high. Thus, the accounting was carried out after the use of the soil preparation Frontier® Optima e.c. showed that its use reduced weed infestation by cereal weeds by 94% compared to controls. After application of the herbicide Korum + surfactant Metholate, the number of cereal weeds in soybean crops decreased to 1 piece / m2, which is 97% less than the original. The use of this method of weed control has allowed to get rid of them almost completely - in soybean crops at harvest time.

Thus, the application of soil herbicides and post-emergence herbicides have quite good results in the destruction of weeds in soybean agrocenoses, and due to foliar application of micronutrients soybean plants grew and developed better and shaded the remaining weeds.

Productivity is the main performance indicator of scientific research. The effect of a set of conditions of growth and development on plants is manifested in changing the parameters of the elements of their productivity.

It should be noted that the introduction of micronutrients promotes better growth and development of soybean plants, which ultimately affects the increase in soybean productivity. Microfertilizers containing molybdenum help to prolong the growing season of soybean plants. Molybdenum (Mo) is a component of nitrate reductase enzymes, which are involved in the reduction of nitrates to ammonia in root and leaf cells. If this element is not enough, a lot of nitrates accumulate in plant tissues, their recovery is delayed, resulting in disruption of normal nitrogen metabolism; after the application of nitrate fertilizers, the need of plants for molybdenum is much higher than ammonia fertilizers. Under the influence of molybdenum for the formation of amino acids and proteins, ammonia is used more intensively by the plant.

Table 3

Soybean seed yield depends on exposure herbicides and microfertilizers, t / ha

Application options	Seed yield, t / ha			Increase in control	
	2019 year	2020 year	Average	t/ha	%
Control (without processing)	1,21	0,82	1,02	-	-
Frontier® Optima e.c., 1,0 l/ha	2,52	1,65	2,09	+ 1,07	105
Corum l.c., 1,5 l/ha + surfactant Metholate, 1,0 l/ha	3,06	2,08	2,57	+ 1,55	152
Frontier® Optima e.c., 1,0 l/ha +Corum l.c., 1,5 l/ha + surfactant Metholate, 1,0 l/ha	3,20	2,35	2,78	+ 1,76	173
Frontier® Optima e.c., 1,0 l/ha + Corum l.c., 1,5 l/ha + surfactant Metholate, 1,0 l/ha + Quantum – Molybdenum Chelate (Mo), 0,5 l/ha	3,34	2,54	2,94	+ 1,92	188
HIP $_{05}$	0,17 0,16				

As can be seen from the above data, the highest soybean yield was in the variant with the introduction of soil Frontier®Optima e.c., 1,0 l/ha – 2,09 t/ha, Corum l.c., 1,5 l/ha + surfactant Metholate, 1,0 l/ha + Quantum - Molybdenum Chelate (Mo), 0.5 l / ha - the level of soybean seed yield was on average for two years - 2.94 t / ha, which is more than in the control areas by 1.92 t / ha or 188 % (Table 4.3).

Therefore, these drugs are quite effective in soybean crops, as they increase yields and reduce weeds.

An important condition is not only to increase the yield of soybeans, but also to improve the quality of grain, in particular the content of proteins and oils. Therefore, it was important to trace the effect of the studied drugs on the formation of the mass of 1000 seeds, the content of proteins and oils in the grain. Soybean growing conditions affect the chemical composition of soybean grain. Protein accumulates more intensely at high temperatures.

Studies have shown that the mass of 1000 soybean seeds under the action of the herbicide Frontier® Optima e.c., 1.0 l / ha was 145 g and increased against the control by 15 g. 5 l / ha in the budding phase in soybean crops contributed to an increase in the weight of 1000 seeds against the control of 29 g.

Analyzing the content of proteins and oils in soybeans, it was found that in variants with the introduction of post-emergence herbicide Corum l.c at the rate of 1.5 l / ha, the protein content was 32.3%, respectively, for the oil content of 21.3%. With the use of soil herbicide Frontier® Optima e.c., 1.0 l / ha - 2.09 t / ha, Corum l.c., 1.5 l / ha + surfactant Metholate, 1.0 l / ha + Quantum - Molybdenum Chelate (Mo), 0.5 l / ha the protein content was at the level of 33.8%, oil - 22.8% (Table 4).

Table 4

The quality of the harvest with the use of herbicides and microfertilizers (average of 2019–2020)

Experiment options	Weight of 1000 seeds, g	Grain content,% on dry matter	
		proteins	oil
Control (without processing)	130	31,1	19,2
Frontier® Optima e.c., 1,0 l/ha	145	32,1	21,2
Corum l.c., 1,5 l/ha + surfactant Metholate , 1,0 л/га	146	32,3	21,3
Frontier® Optima e.c., 1,0 l/ha + Corum l.c., 1,5 l/ha + surfactant Metholate, 1,0 л/га	157	33,2	22,4
Frontier® Optima e.c., 1,0 l/ha + Corum l.c., 1,5 l/ha + surfactant Metholate, 1,0 l/ha + Quantum – Molybdenum Chelate (Mo), 0,5 l/ha	159	33,8	22,8

The obtained data give grounds to assert that the formation of higher protein and oil content in the variants of the experiment with the use of the studied drugs is the result of creating more favorable conditions for soybean plants in physiological and biochemical processes and microbiological - in plants and soil.

Conclusions.

1. The weed control efficiency 60 days after application of Frontier® Optima was 75% compared to the control. Before harvest, weeds in soybean crops were in the range of 26 pieces / m^2. This figure is 72% lower compared to weeds in the control version, where at the time of harvest there were 94 pieces / m^2 of weed plants.

2. Accounting conducted 30 days after spraying the crops showed that the efficiency of Corum® 1.5 l / ha in soybean crops was 89%. The total number of weeds decreased by 93% at the time of harvest compared to the original, which proves the high effectiveness of the drug to eliminate weeds in soybean crops.

3. The combination of pre-emergence and post-emergence use of the studied drugs had a greater phytotoxic effect on the main weed species in soybean crops. Thus, cereal weeds were destroyed by 100%, Amaranthus retroflexus by 93%, and Chenopódium álbum by 94%. It should be noted in areas where the composition was introduced Frontier® Optima e.c., + Corum l.c. + Metholate + Quantum-Molybdenum Chelate The phytotoxic effect on weeds increased, and soybean plants grew and developed better in the future. Weed control rates for soybean weeds were 94-100% compared to control plots during the soybean harvest period.

4. The highest soybean yield was in the variant with the application of soil herbicide Frontier® Optima e.c., 1.0 l / ha - 2.09 t / ha, Korum l.c., 1.5 l / ha + surfactant Metholate, 1, 0 l / ha + Quantum - Molybdenum Chelate (Mo), 0.5 l / ha - the level of soybean seed yield averaged 2.94 t / ha in two years, which is 1.92 t / ha more than in the control plots. ha or 188%.

5. Studies have shown that the mass of 1000 soybean seeds under the action of the herbicide Frontier® Optima e.c., 1.0 l / ha was 145 g and increased against the control by 15 g. 5 l / ha in the phase of the beginning of budding in soybean crops contributed to the growth of the mass of 1000 seeds against the control of 29 g.

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