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Section 1. Agricultural sciences

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INFLUENCE OF ENDOPHYTIC-RHIZOBIAL INOCULATION ON THE FORMATION OF LEAF SURFACE AREA, SYMBIOTIC APPARATUS AND YIELD OF SOYBEAN UNDER IRRIGATION CONDITIONS IN THE SOUTH OF UKRAINE

Abstract. The aim of the work was to establish the characteristics of growth and development and formation of yield of soybean varieties of different maturity by inoculation of seeds with nodule and endophytic bacteria under irrigation conditions in the south of Ukraine. Studies established the positive effect of pre-sowing endophytic-rhizobial inoculation of seeds on the formation of the leaf surface, the number and weight of nodules and the yield of the ultra-early variety Diona and mid-early variety Aratta. The highest yield of seeds of soybean varieties was formed by pre-sowing seed treatment with Rizobin^{K}+Bacillus sp.4–2.7 t/ha for variety Diona and 2.9 t/ha for variety Aratta, which is 5.9–8.0 c/ha more than in the control variants.

Keywords: soybean, rhizobia, endophytes, symbiosis, leaf area, yield, irrigation.

1. Introduction

The formation of the yield of agricultural crops, including soybean, depends on many factors and, above all, on the technology of growing crops [1].

Soybean belongs to a group of plants with a short daylight hours and has a high sensitivity to changes in the light regime, and therefore requires intensive lighting of the lower tier of plants, where the main yield of the crop is formed [2]. Sensitivity to changes in the photoperiod becomes noticeable after the development of the first leaves and especially during the period of flowering, when growth processes slow down and nutrients are used mainly for seed formation [3]. From this point of view, each agrotechnical method, aimed at increasing yields, turns out to be effective only if it makes it possible to obtain in crops such a leaf surface that develops rapidly and reaches optimal sizes.

It is important to study the duration of the production processes, the peculiarities of the formation of the leaf surface area, the symbiotic apparatus, the growth and development of soybean varieties of different maturity groups using the latest biotechnological approaches.

2. Materials and methods

Field experiments during 2018–2020 years on dark chestnut medium loam soils of the Askaniya State Agricultural Research Station of the Institute of Irrigated Agriculture of the National Academy of Agricultural Sciences of Ukraine under irrigation conditions were conducted.

The two-factor field experiment was based on the split-plots method, where the main plots (first-order plots, factor A) were soybean varieties (ultra-early variety Diona and mid-early variety Aratta), the subplots (second-order plots, factor B) were the following options for seed treatment: Control 1 (without seed treatment); Control 2 (treatment of seeds with water); Rizobin^K (association of strains *Bradyrhizobium japonicum* UCM B-6018, UCM B-6023, UCM B-6035); Rizobin^K + *Paenibacillus* sp. 1; Rizobin^K + *Bacillus* sp. 4; Rizobin^K + *Brevibacillus* sp. 5; Rizobin^K + *Pseudomonas* sp. 6; Rizobin^K + *Bacillus megaterium* UCM B-5724. For the inoculation were used the strains from the collection of microorganisms of the Department of General and Soil Microbiology of the Zabolotny Institute of Microbiology and Virology of the NAS of Ukraine. The sowing rate of Diona seeds was 800,000 and the sowing rate of Aratta seeds was 600,000 seeds per 1 ha. Seeds treatment with the complex inoculants was carried out on the day of sowing with a bacterial load of 10^7 cells per seed. Statistical analysis of experimental data by the method of variance and correlation analysis was performed [4].

3. Results and discussion

The abiotic stresses associated with extreme climate change cause the need to develop technologies to stabilize crop production and increasing agricultural productivity. Along with irrigation, biotechnologies based on rhizobacteria and endophytes that can promote growth and increase stress resistance of plants are promising [5–7].

During the pre-sowing treatment of seeds with the latest inoculants, a significant increase in the assimilation surface of the leaves of both studied soybean varieties was observed already in the interphase period "beginning of branching-beginning of flowering" (Table 1).

Table 1. – Leaf surface area by phases of growth and development of soybean depending on the complex inoculation, thousand m²/ha (average for 2018–2020 y.)

Variety (A)	**Bacterial preparations (B)**	**Leaf surface area, thousand m²/ha**		
		the beginning of branching-the beginning of flowering	**the beginning of flowering- the beginning of bean formation**	**the beginning of bean formation-the beginning of bean ripening**
1	***2***	***3***	***4***	***5***
Diona	Control 1	11.4	22.3	25.7
	Control 2	11.9	22.7	26.9
	Rizobin^K	15.2	31.5	36.6
	Rizobin^K + *Paenibacillus* sp.1	15.7	31.3	37.2
	Rizobin^K + *Bacillus* sp.4	18.3	36.4	42.1
	Rizobin^K + *Brevibacillus* sp.5	19.2	34.3	39.3

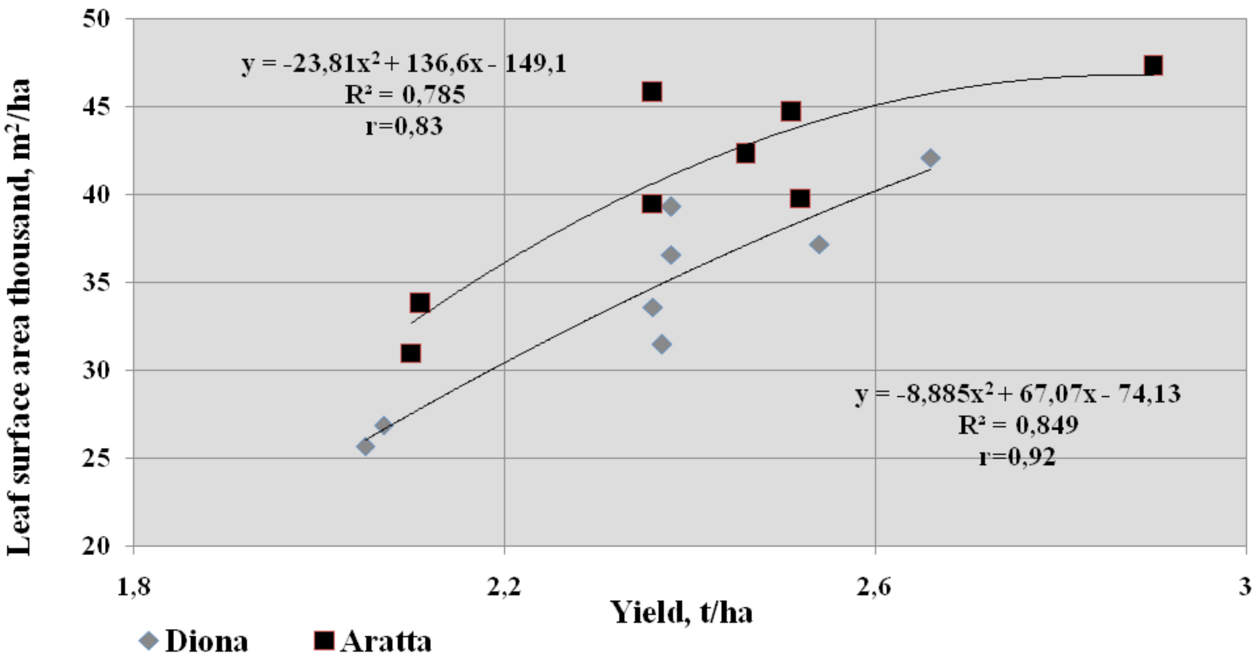
1	*2*	*3*	*4*	*5*
Diona	Rizobin^K + *Pseudomonas* sp.6	16.1	32.4	33.6
	Rizobin^K + *Bacillus megaterium* UCM B-5724	17.6	30.9	31.5
Aratta	Control 1	10.8	25.4	31.0
	Control 2	11.8	27.4	33.8
	Rizobin^K	14.7	32.6	39.5
	Rizobin^K + *Paenibacillus* sp.1	14.8	35.3	45.8
	Rizobin^K + *Bacillus* sp.4	14.9	36.0	47.3
	Rizobin^K + *Brevibacillus* sp.5	14.8	35.9	44.7
	Rizobin^K + *Pseudomonas* sp.6	12.6	34.0	39.8
	Rizobin^K + *Bacillus megaterium* UCM B-5724	13.5	36.1	42.3
	LCD_{05} Diona variety LCD_{05} Aratta variety	2.29 1.29	4.13 3.38	4.70 4.66

The increase in leaf area of the Diona variety in the variant with Rizobin^K was 3.3–3.8 thousand m^2/ha compared with control variants; with composition Rizobin^K + *Paenibacillus* sp.1–3.8–4.3; Rizobin^K + *Bacillus* sp.4–6.4–6.9; Rizobin^K + +*Brevibacillus* sp.5–7.3–7.8; Rizobin^K + *Pseudomonas* sp. 6–4.2–4.7 thousand m^2/ha. During the cultivation of Aratta soybeans, this indicator increased in the variant with Rizobin^K by 2.9–3.9 thousand m^2/ha, with Rizobin^K + *Paenibacillus* sp.1 – by 3.0–4.0; Rizobin^K + *Bacillus* sp.4 – by 3.1–4.1; Rizobin^K + *Brevibacillus* sp.5 – by 3.0–4.0; Rizobin^K + *Pseudomonas* sp.6 – by 0.8–1.8 thousand m^2/ha. In the interphase period "beginning of flowering-beginning of bean formation" the leaf surface area of the studied varieties in variants with inoculation increased by 19.0 – 38.8% with the use of Rizobin^K; by 28.8 – 37.9% – complex inoculant Rizobin^K + *Paenibacillus* sp.1; by 31.4–60.3% – Rizobin^K + *Bacillus* sp.4; by 31.0–51.1% – Rizobin^K + *Brevibacillus* sp.5; by 24.1–42.7% – Rizobin^K + + *Pseudomonas* sp.6.

The maximum leaf surface area of soybean varieties Diona and Aratta was formed in the interphase period "the beginning of the bean formation-the beginning of bean-ripening", which in the variant with Rizobin^K reached 36.6–39.5 thousand m^2/ha, respectively, with bioformulation Rizobin^K + *Paenibacillus* sp.1–37.2–45.8; Rizobin^K + *Bacillus* sp.4– – 42.1–47.3; Rizobin^K + *Brevibacillus* sp.5–39.3– – 44.7; Rizobin^K + *Pseudomonas* sp. 6–33.6–39.8 thousand m^2/ha. Correlation-regression analysis of experimental data revealed a close positive intercourse between Diona and Aratta soybean yield and leaf surface area (Picture 1).

Previously, the ability of endophytic soybean bacteria to stimulate the formation of soybean-rhizobial symbiotic systems in the vegetation experiment was shown [8]. When studying the effect of endophytic-rhizobial inoculation on the activation of soybean symbiosis with nodule and endophytic bacteria in field experiments under irrigation, an increase in the number and mass of nodules on the root system by interphase periods was found (Table 2).

In the branching phase, almost the same number and mass of nodules on the root system of Diona and Aratta varieties were formed. The maximum number of nodules on both soybean varieties was in the variant with seed inoculation with the complex inoculant Rizobin^K + *Bacillus* sp. 4 and exceeded the control indicators by 65–75%.



Picture 1. Correlation dependence of Diona and Aratta soybean seed yield on leaf surface area (average for 2018–2020 y.)

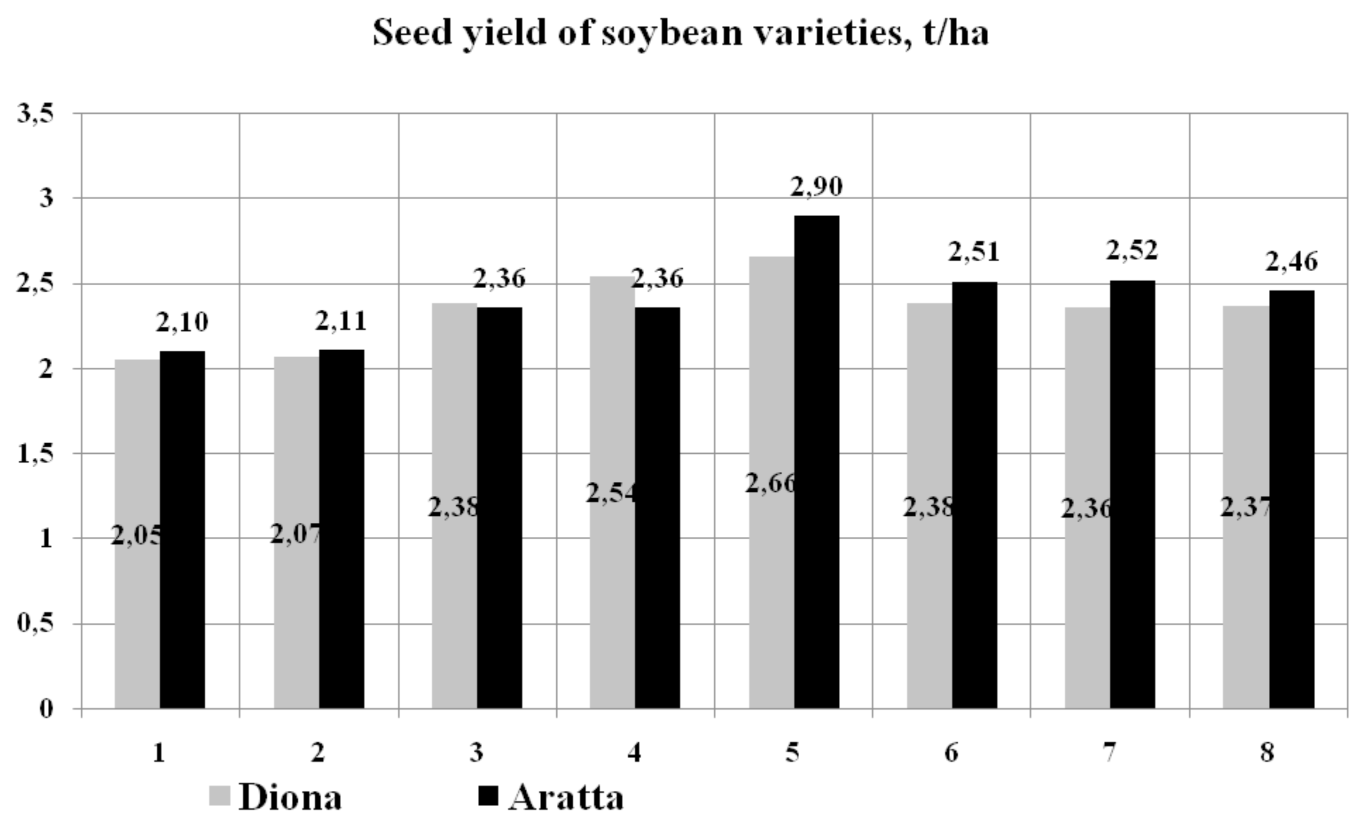
In the phase of bean formation in the variants where seed inoculation was carried out, the number of nodules in both soybean varieties exceeded the control values by 20–29 pieces by *Paenibacillus* sp.1 coinoculation, 21–37 pcs.– by *Bacillus* sp.4 coinoculation, 12–16 pcs.– by *Brevibacillus* sp.5 coinoculation and 16–17 pcs.– by *Pseudomonas* sp. 6 coinoculation together with rhizobia.

The highest yield of soybean varieties was obtained by inoculation of seeds with the composition Rizobin^K + *Bacillus* sp.4, which during growing Diona variety on average for 2018–2020 y. was 2.66 t/ha and Aratta variety – 2.90 t / ha, which is 5.9–8.0 c/ha more than in the control variants (Picture 2).

Table 2. – Influence of endophytic-rhizobial inoculation of seeds on the formation of the number and mass of nodules on the root system of different maturity soybean varieties (average for 2018–2020 y.)

Variety (A)	Bacterial preparations (B)	The number and mass of nodules per 1 root of the plant			
		branching		formation of beans	
		number of nodules, pcs.	nodules mass, g	number of nodules, pcs.	nodules mass, g
1	2	3	4	5	6
Diona	Control 1	20	0.34	31	0.78
	Control 2	22	0.43	33	0.89
	Rizobin^K	27	0.61	54	1.22
	Rizobin^K + *Paenibacillus* sp.1	29	0.60	60	1.24
	Rizobin^K + *Bacillus* sp.4	33	0.68	68	1.35

1	*2*	*3*	*4*	*5*	*6*
Diona	Rizobin^K + *Brevibacillus* sp.5	32	0.66	47	1.20
	Rizobin^K + *Pseudomonas* sp.6	27	0.62	48	1.17
	Rizobin^K + *Bacillus megaterium* UCM B-5724	27	0.62	52	1.21
Aratta	Control 1	20	0.32	37	1.06
	Control 2	22	0.45	39	1.18
	Rizobin^K	26	0.51	46	1.35
	Rizobin^K + *Paenibacillus* sp.1	24	0.53	51	1.31
	Rizobin^K + *Bacillus* sp.4	35	0.59	58	1.47
	Rizobin^K + *Brevibacillus* sp.5	27	0.59	49	1.19
	Rizobin^K + *Pseudomonas* sp.6	25	0.47	53	1.43
	Rizobin^K + *Bacillus megaterium* UCM B-5724	27	0.50	47	1.24
	LSD_{05} Diona variety	3.60	0.10	10.15	0.16
	LSD_{05} Aratta variety	3.61	0.07	5.64	0.11



Picture 2. Yield of different maturity groups of soybean varieties by endophytic-rhizobial inoculation of seeds under irrigation of the Southern Steppe of Ukraine, t/ha (average for 2018–2020 y.): 1 – Control 1 (without seed treatment); 2 – Control 2 (seed treatment with water); 3 – Rizobin^K; 4 – Rizobin^K + *Paenibacillus* sp.1; 5 – Rizobin^K + *Bacillus* sp.4; 6 – Rizobin^K + *Brevibacillus* sp.5; 7 – Rizobin^K ++ *Pseudomonas* sp. 6; 8 – Rizobin^K + *Bacillus megaterium* UCM B-5724

Conclusions

Thus, the complex inoculation of seeds with nodule and endophytic bacteria contributed to the formation of a larger assimilation surface of the leaves, better development of the symbiotic apparatus, increasing the productivity of the studied soybean varieties of different maturity groups.

Coinoculation by endophytic bacteria of soybean *Bacillus* sp.4 together with rhizobia is an effective biotechnological approach in the cultivation of soybeans under irrigation of the Southern Steppe of Ukraine.

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USE OF MACROELEMENTS BY BELLADONNA PLANTS BY STAGES OF DEVELOPMENT

Abstract. The need for research of technologies for growing Belladonna vulgaris as a medicinal raw material is justified. The peculiarities of Belladonna plant nutrition at different stages of development are studied. The use of microelements depending on the physiological needs of plants is analyzed. The dynamics of changes in mineral nutrition compounds in plant tissues depending on the stages of organogenesis is given. It was found that the concentration of compounds in plant tissues varied and reached its maximum values before the generative stage of organogenesis. The obtained results show the dynamics of the concentration of mineral nutrition compounds in the dry matter of different parts of Belladonna plants in the process of their growing season. Accordingly, the need for mineral nutrition compounds depended on the stages of organogenesis that plants underwent.

Keywords: stages of organogenesis, roots, bio-raw materials, nitrogen, potassium, phosphorus compounds.

Problem statement. According to the World Health Organization, a significant part of the population uses herbal medicines in the treatment of various diseases. In medical practice, the share of herbal medicines in developed countries is about 60–70%. One of the priorities of modern medical science is the creation of modern, highly effective phytopreparations that do not have negative side effects. Therefore, it is important to expand the search for natural sources of biologically active compounds and create medicines based on them.

Belladonna vulgaris – *Atropa Belladonna* L. refers to medicinal plants that have long been used in folk medicine and have a wide range of pharmacological action. The effect of Belladonna plant on the body is determined by the predominant action of atropine and scopolamine [1; 2]. Belladonna preparations are widely used in medical practice as antispasmodics and analgesics for gastroduodenal ulcer, cholecystitis, cholelithiasis, renal colic, in ophthalmic practice – for mydriasis and paralysis of accommodation, as well as in other diseases associated with disorders of the autonomic nervous system (Mashkovsky, 1988; Atlas of Medicinal Plants of Russia, 2006; Kortykov, 1997; Mykhailov, 2003; Krepkova et al., 2004; Anetzhofer, 1990). In order to provide the medical industry with Belladonna raw materials, its industrial cultivation was previously concentrated in the Crimea, Ukraine and the North Caucasus. With the collapse of the USSR, having lost the main growing areas, there was a need to promote this plant in more northern areas, in particular, in the Central Black Earth region of Russia. The relevance of the work is determined by the stable demand for medicinal raw materials of Belladonna and the need to create a domestic raw material base. Belladonna vulgaris – *Atropa Belladonna L.* is a well-known medicinal plant that is widely used in pharmacology and folk medicine. At the same time, Belladonna plants are characterized not only by high therapeutic activity, but also by high toxicity for both humans and most warm-blooded animals [1; 2]. Therefore, handling Belladonna plants requires appropriate care.

At the same time, the need for Belladonna as a medicinal and pharmaceutical raw material is constantly growing [3], so the need to develop a modern and effective technology for growing crops of such a plant is urgent.

An important component of any technology for growing cultivated plants, including medicinal ones, is the development of an effective system of mineral nutrition of such crops. As a basis of such system it is most expedient to use physiological needs of plants, first of all in macroelements (NPK). The volume of needs and their mutual structure in mineral nutrition can be established by analyzing the content of necessary compounds in the main parts of Belladonna plants by stages of their organogenesis, especially in the first half of the growing season, when the assimilation of basic volumes of these compounds (more than 60–70%)) until the end of the generative stage of organogenesis [4; 5].

Based on the following objective provisions in the process of research planning, it was envisaged to analyze the content of common mineral nutrition compounds in Belladonna plants at different stages of organogenesis: in juvenile plants (underground parts and tops), at the generative stage (underground parts and tops) and at the senile stage (seeds, tops and roots).

Materials and methods. The research was performed at the Institute of Horticulture of the National Academy of Agrarian Sciences and the Institute of Plant Physiology and Genetics of the National Academy of Sciences of Ukraine during 2017–2019. Field research was carried out in the hospital laboratory of ornamental, medicinal and essential-oil-bearing plants of the Institute of Horticulture of the National Academy of Agrarian Sciences. The terrain of the experimental site is flat. The soil is dark-gray podzolic, middle loamy on carbonate loess, typical for the northern part of the Forest-Steppe of Ukraine. Soil analysis was performed in the laboratory of agrochemistry of the Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine. The content of humus in the arable layer (0–40 cm) is 2.3%, easily hydrolyzed nitrogen (according to Tiurin and Kononova) from 78.4 to 98.0 mg/kg, active forms of phosphorus – 93.2–180.9 mg/kg, exchangeable potassium (according to Kersanov) – 106.1–202.8 mg/kg.

The reaction of their soil solution is acidic (pH 5.3–5.8 and 5.5–6.1, respectively).

The total area of the plot was 20 m^2, accounting – 6 m^2, number of replications – four.

Soil preparation, planting seedlings and plant care were carried out according to the recommendations developed by the authors for Belladonna growing in the Forest-Steppe [6].

Weather conditions in the years of research differed significantly in temperature, precipitation and humidity, which had significant deviations from the average long-term norm, which provided an opportunity to more fully study the biological and morphological characteristics of Belladonna plants, their adaptability to growing conditions and ability to realize biological potential.

Plant care during all the years of research consisted of loosening row spacing 2–3 times and removing weeds. Watering of plants during their growing season was carried out only during the long period of rainlessness, mainly in July 2017.

Sampling of juvenile Belladonna plants was carried out during the formation of 4 real leaves. Samples were taken in 4 replicates of 20 plants in each replicate. In the selected plants, the roots were washed from soil particles and then dried with filter paper to an air-dry state.

The study of the nitrogen compounds (total nitrogen) in the tops of plants was carried out by the method of «wet ashing» according to Ginzburg on the Sereniev device. The selected plants were cut and divided into underground parts and tops. Each of them was prepared for analysis separately.

The samples were crushed and weighed portions of 50 g each were made. The weighed portions were placed in sample bottles and dried in heating cabinet at a temperature of 114 ^{0}C during the day. The resulting dry mass was weighed again and ground. A portion of one gram was taken from the ground dry mass for «wet ashing» (according to Ginzburg). After combustion, samples were taken from the resulting solution for analysis of the presence of nitrogen compounds (total nitrogen) in the samples on the Serenev device.

The presence of other macroelements was carried out at the Institute of Plant Physiology and Genetics of the National Academy of Sciences of Ukraine and determined by the ICP-MS method on an Agilent 7700x emission mass spectrometer. The samples were dried to a dry mass and ashed in nitric acid (ACS) using microwave sample preparation Milestone Start D. All solutions were prepared on water of the 1st class (18 Meg · cm), prepared on a water purification system Scholar-UV Nex Up 1000 Corporation, Korea).

The results of the experiments were processed statistically according to standard methods [7; 8], using the program Exel and with mathematical processing of the obtained data using a professional software suite Statistica 8.0. for statistical analysis.

Research results and their discussion. The processes of germination of Belladonna seeds began with the active absorption of soil moisture by soil tissues (primarily by corcule cells). The presence of a sufficient amount of water in combination with the presence of the required level of temperature and the presence of oxygen in the air activated primarily the processes of hydrolysis, movement of substances, provided the ability of active work of enzyme proteins, respiration and synthesis of ATP molecules. On the basis of such processes, the active fission of corcule meristem cells and their subsequent differentiation into all other types of tissues began.

To ensure the processes of such qualitative changes, the sprout uses phytins present in the seeds as a source of phosphorus. Since their reserves are limited, the main root, which develops from the structures of the seminal root, together with water begins the assimilation of water-soluble available phosphorus compounds from the soil solution. Assimilation of phosphorus anions occurs by active transfer across the biological membranes of root hairs and requires energy (in the form of ATP molecules). The synthesis of new ATP molecules takes place in the mitochondria of root hairs, where the oxidation of glucose molecules results in the free energy of chemical bonds. To carry out active respiration, it is necessary to receive oxygen molecules from the air present in the arable layer of the soil [9]. Therefore, for the successful germination process of Belladonna seeds, in addition to the presence of moisture and sufficient temperature, sufficient soil aeration is necessary.

After the appearance of Belladonna sprouts on the soil surface and the removal of the cotyledons of seeds by the hypocotyl to light, they begin to carry out the processes of photosynthesis. Juvenile plants gradually switch to autotrophic nutrition using the energy of sunlight. Such changes are associated not only with energy factors, but also with the processes of active growth. Accordingly, with the high needs of juvenile plants for available phosphorus compounds, the needs for nitrogen compounds become a priority. It is known that belladonna plants, like other green plants, successfully absorb various forms of nitrogen compounds: nitrates, ammonium and amide [10]. Nitrates and amide nitrogen compounds in water are dissociated into ions and are anions for the assimilation of which plants use active membrane transfer. Ammonium forms in the process of dissolution in water form cations that enter the cytoplasm of plant root hairs passively, that is, without energy consumption [11]. Juvenile Belladonna plants simultaneously absorb all of the present forms of nitrogen compounds in the soil. Nitrogen compounds are essential components in the synthesis of amino acids and proteins in plant cells. A sufficient number of nitrogen compounds ensures the implementation of active growth processes of vegetative organs of plants: sprouts, leaves, roots.

To carry out active processes of growth and development of juvenile Belladonna plants, a mandatory component of mineral nutrition is the presence of a sufficient amount of potassium compounds. Potassium compounds are little part of the synthesized organic substances. However, potassium, as an alkali metal with the highest chemical activity, performs very important functions in young plants [12]. It is potassium compounds that provide the necessary level of water presence in the cytoplasm of cells and the corresponding turgor, potassium compounds contribute to the implementation of intensive metabolic processes both in cells and in tissues and between the main parts of plants. The presence of potassium compounds increases the resistance of plants to adverse growing conditions: high and low temperatures, the presence of pathogens, and others.

Assimilation of potassium compounds present in the soil solution by plants occurs by passive membrane transfer through the biological membranes of root hairs to the cytoplasm, such processes do not require energy.

As a result of the analysis, it was found that the content of total nitrogen compounds in the roots of Belladonna plants was 2679.64 mg/kg and in the tops, respectively, 2833.46 mg/kg (Table).

Table 1. – Dynamics of the concentration of mineral nutrition compounds in the dry mass of Belladonna vulgaris during the growing season 2017–2019

Mineral nutrition compounds	**Parts of plants**		
	seeds	**roots**	**tops**
Juvenile stage of organogenesis			
N	–	2679.64	2833.46
P_2O_5	–	1256.38	1366.42
K_2O	–	2792.19	2955.53
Generative stage of organogenesis			
N	–	2765.13	2976.64
P_2O_5	–	1311.17	1547.36
K_2O	–	2835.52	3212.51
Senile stage of organogenesis			
N	3889.42	6818.81	2764.33
P_2O_5	4580.67	1397.15	1485.23
K_2O	4629.73	7928.79	3192.14

Phosphorus compounds in the roots are 1256.38 mg/kg and in the tops are 1366.42 mg/kg.

The largest amount of potassium compounds was recorded in the roots of Belladonna plants 2792, 19 mg/kg and in the tops – 2955.53 mg/kg.

During the growing season, the concentration of mineral nutrition compounds in plant tissues varied and reached its maximum by the generative stage of organogenesis.

In the roots (underground parts of belladonna plants) the content of nitrogen compounds showed a tendency to increase and amounted to 2765.13 mg/kg or 3.2% compared to the level of previous analyzes.

The concentration of phosphorus compounds in the roots also increased and amounted to 1311.17 mg/kg, or 4.4% more than the indicators of analyzes at the juvenile stage of organogenesis of Belladonna plants.

The concentration of potassium compounds in the roots was 2835.52 mg/kg or compared to previous analyzes has changed a little. The upward trend was 1.6%.

Changes in tops of plants at the generative stage of organogenesis were more significant. During the previous stages (virginile and generative, respectively) inflorescences and flowers of plants were formed, ie there were changes that required the active use of phosphorus compounds in the presence of sufficient amounts of assimilation of nitrogen and potassium compounds.

The content of nitrogen compounds in the tops of plants was at the level of 2976.64 mg/kg or the increase in concentration was 5.1%. The content of phosphorus compounds in the tissues reached 1547.36 mg/kg or 13.2% more than the level of the presence of this element in the tissues at the juvenile stage of organogenesis.

The presence of potassium compounds in the tops of plants at the generative stage of organogenesis was 3212.51 mg/kg, or increased by 8.7%.

The next growing season of Belladonna vulgaris in the first year of growth and development completed the annual life cycle of perennials. After flowering, the plants formed fruits (berries) and seeds. The formed organic substances were appropriately translocated to fruits and seeds and to underground parts of plants to form a depot for the period of physiological rest in the cold season. Therefore, after ripening, the content of mineral nutrition compounds in the seeds, roots and tops of Belladonna plants was analyzed.

The content of nitrogen compounds in the seeds was 3889.42 mg/kg, which indicates the concentration of macronutrients (primarily proteins) in the cotyledons.

The presence of phosphorus compounds even exceeded the content of nitrogen compounds and reached 4580.67 mg/kg. The highest concentration of potassium compounds was 4629.73 mg/kg.

In the underground parts of Belladonna plants, the concentration of nitrogen compounds was recorded at 6818.81 mg/kg, or compared to previous records, it increased by 146.6%. This increase in the content of nitrogen compounds can be explained by the formation of a depot of macronutrients in the underground (perennial) parts of plants. The concentration of phosphorus compounds in the underground parts of plants was 1397.15 mg/kg or compared to previous records increased by 6.6%.

The presence of potassium compounds in the underground parts of Belladonna plants at the end of the growing season reached 7928.79 mg/kg.

In the tops of plants as a result of moving part of the macronutrients in fruits, seeds and underground parts, the concentration of nitrogen compounds decreased and amounted to 2764.33 mg/kg or was lower than in previous calculations by 7.1%.

There was also a decrease in the presence of phosphorus compounds. In the tops of plants, their concentration was 1485.23 mg/kg or compared to previous records decreased by 4.0%.

The presence of potassium compounds in the tops at the end of the growing season was 3192.14 mg/kg, or compared to the previous accounting indicators, it showed a downward trend in the range of 0.6%.

The results obtained in figures demonstrate the lability of the concentration of mineral nutrition compounds in the dry matter of various parts of Belladonna plants during their growing season. Accordingly, the need for mineral nutrition compounds depended on the stages of organogenesis that plants underwent.

Reserves of available mineral nutrition compounds in the arable soil layer in the appropriate proportions that are optimal for ensuring the growth and development of plants of such a valuable medicinal plant as Belladonna, should be formed before the creation of crops.

Conclusions

1. The amount of potassium compounds in the roots of Belladonna vulgaris at the level of 2792.19 mg/kg and tops at the level of 2955.53 mg/kg at the juvenile stage of development ensured the activity of plant growth processes.

2. During the growing season, the concentration of mineral nutrition compounds in plant tissues varied and reached its maximum by the generative stage of organogenesis.

3. The level of accumulation of nitrogen compounds in seeds – 3889.42 mg/kg (senile stage of organogenesis) indicates a sufficient concentration of macronutrients in the cotyledons of Belladonna plants.

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Section 2. Technical sciences

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MATRICES IN ENVIRONMENTAL ENGINEERING

Abstract

Modern ecology intensively studies the problems of human-environment interaction. Ecologists consider the biosphere and related human activities in a unified nature-society system as humanity's ecological niche, of which they identify as one of the key challenges in managing the rational relationship between humans and the environment. The technological revolution not only exacerbates the contradictions between society and nature, but also creates great opportunities to resolve them by eliminating the adverse effects of human activity. Where environmental education of the whole way of life is of paramount importance, it is not possible to solve environmental problems by specialists alone.

One of the fundamental processes of applied scientific research in ecology is methodologies for modelling and forecasting the development of ecosystems over given time intervals. By using mathematical modelling in human-environment relations, it is possible to achieve a sustainable equilibrium in the balance of ecosystems without strictly capturing subsequent changes from past interactions in the present timescale.

Purpose: Determining how to predict ecological systems with a long lifetime using mean Q-matrices.

Methodology in article analytical as well as mathematical methods of analysis were used.

Results: the fundamental properties of qualitative mathematical models of ecosystems are identified and analysed analytically.

Practical implications the results obtained are appropriate for use in modelling environmental processes in predicting the state of the systems in terms of the sustainability parameter.

Keywords: ecological systems, matrices, mathematical modelling, forecasting.

Introduction

Environmental ecology is literally defined in Greek as the study of habitat and is one of the youngest scientific fields in the study of populations, communities and ecosystems. Nevertheless, the formation and establishment of ecology as a science took place on the basis of other more developed fields of study of natural objects, phenomena and processes, such as biology, geography, physics, chemistry and other natural sciences [13]. Drawing on other sciences, ecology has naturally absorbed the techniques and research methods made in the 'parent' sciences [1]. This applies in full to research on mathematical and theoretical methods [6].

Matrices in environmental engineering

Environmental issues need to be addressed at every stage of industrial production in tandem with other challenges, and this is only possible if environmental knowledge becomes an integral part of the world of engineers, technologists and other professionals [14].

The use of the idea of a community matrix is that it makes it easier to represent and quantify the interactions between members of any community.

The concept of the community matrix is virtually independent of the Lotka-Volterra competition equations [9], as it can just as easily be formulated based on the sensitivity of the population size of each species to changes in the density of the other species (accepting the conditions necessary to reverse all signs of the matrix.

A Markov chain model

Markov models are a type of stochastic model [2]. They are closely related to matrix models, as their basic construction is a matrix, but whose elements are not deterministic, but probabilistic transitions from one state to another. The sum of the probabilities for all rows is one [10].

The advantages of Markov-type models are as follows:

1. Such models are relatively easy to build from sequence data.

2. Markov models do not require an in-depth understanding of the inner workings of dynamic change in the system, i.e. they serve as a kind of reference point for further research.

3. The main transition probability matrix depicts the main parameters of dynamic changes in the system in a way that few other types of models can.

4. The results of the analysis of Markov models can easily be presented graphically, which makes them clearer and more understandable.

5. The computational requirements for studying Markov models are rather modest, especially for a small number of states.

The disadvantages of these models include the following:

1. Lack of reliance on functional mechanisms, which makes models less attractive to environmentalists.

2. The deviation from steady state that results from the assumption of first order Markov chains. Although this is possible in principle in the case of direct Markov models, it leads to excessive difficulties in the analysis and calculations.

3. In some cases, there is insufficient data to reliably estimate the probability or speed of transition.

4. As with other models, the question of the adequacy of the model depends on the ability to predict the modification of the system. To do this by the same processes; covering a sufficiently long period is difficult.

The main task of building Markov models is to collect data to calculate transition probabilities and compile transition matrices, which requires information on changes occurring at regular intervals and responses to different types of perturbation [7]. Consider the Markov model for analysing the success of a bog ecosystem using the work of A. V. Nemchinova [5] and J. N. R. Jeffers [12] as an example.

Table 1.– Estimated probability of transitions between the four possible states over a period of 20 years in Taiga

Portion in the initial state	**The probability of transition to the final state**			
	1. Swamp	**2. *Calluna vulgaris***	**3. Forrest**	**4. Area is eaten away by large herbivores**
1	**2**	**3**	***4***	***5***
1. Swamp	0.650	0.29	0.06	0

1	2	3	4	5
2. *Calluna vulgaris*	0.3	0.33	0.3	0.07
3. Forrest	0	0.28	0.69	0.03
4. Area is eaten away by large herbivores	0	0.4	0.2	0.4

Note: that the matrix model represents a transition from one state to another in a time step of 20 years. The transition probabilities for the two-time steps can be obtained by multiplying the one-step matrix by itself, so that in the simplest case the two states correspond to the probabilities determined by the matrix:

$$\begin{vmatrix} \boldsymbol{P}_{11}^{(2)} & \boldsymbol{P}_{12}^{(2)} \\ \boldsymbol{P}_{21}^{(2)} & \boldsymbol{P}_{22}^{(2)} \end{vmatrix} = \begin{vmatrix} \boldsymbol{P}_{11} & \boldsymbol{P}_{12} \\ \boldsymbol{P}_{21} & \boldsymbol{P}_{22} \end{vmatrix} \times \begin{vmatrix} \boldsymbol{P}_{11} & \boldsymbol{P}_{12} \\ \boldsymbol{P}_{21} & \boldsymbol{P}_{22} \end{vmatrix} \quad (1)$$

or compressed (matrix) form:

$$\boldsymbol{P}^{(2)} = \boldsymbol{P} \times \boldsymbol{P} \quad (2)$$

A three-degree matrix obtained by multiplying a second-order matrix by a first-order matrix:

$$\boldsymbol{P}^{(3)} = \boldsymbol{P}^{(2)} \times \boldsymbol{P} \quad (3)$$

For the general case of n steps we have:

$$\boldsymbol{P}^{(n)} = \boldsymbol{P}^{(n-1)} \times \boldsymbol{P} \quad (4)$$

For our two-stage transition probability matrix:

$$\begin{vmatrix} 0{,}51 & 0{,}30 & 0{,}17 & 0{,}20 \\ 0{,}29 & 0{,}31 & 0{,}34 & 0{,}06 \\ 0{,}08 & 0{,}30 & 0{,}57 & 0{,}05 \\ 0{,}12 & 0{,}35 & 0{,}34 & 0{,}19 \end{vmatrix} \quad (5)$$

If the transition probability matrix is successively exponentiated until each row is the same as all the others, forming a fixed probability vector, we get what is known as a regular transition matrix. This matrix shows to what extent the transition probability from one state to another is independent of the initial state, and a fixed probability vector gives a stationary probability distribution of all states. In this example, the vector is:

$$[0{,}2177 \quad 0{,}2539 \quad 0{,}3822 \quad 0{,}1462] \quad (6)$$

Thus, the ecosystem reaches the end of the equilibrium state in which ≈22% of the area is occupied by marshes and approximately 25, 38 and 15% by *Calluna vulgaris* communities, forests and land eaten by herbivores.

In the absence of absorbing states (as in our case) we are interested in the average time to reach a state first, such as the average time to become a C*alluna vulgaris,* swamp, a forest or a herbivore-eaten area. As a result of the calculations, which are not given here, we obtain a matrix of the average time to reach the first.

$$\begin{vmatrix} 0{,}000 & 3{,}561 & 7{,}197 & 31{,}688 \\ 9{,}566 & 0{,}000 & 5{,}237 & 28{,}755 \\ 13{,}672 & 4{,}107 & 0{,}000 & 29{,}178 \\ 18{,}673 & 9{,}107 & 5{,}000 & 0{,}000 \end{vmatrix} \quad (7)$$

As each time step equals 20 years, the average time required for an area dominated by *Calluna vulgaris* to become a swamp is:

$$9{,}566 \times 20 = 191\,\textit{years} \quad (8)$$

Similarly, the average time required to convert a forest to land dominated by *Calluna vulgaris* is:

$$4{,}107 \times 20 = 82\,\textit{years} \quad (9)$$

In the same way, other times can be calculated.

Finally, knowing the probability vector matrix, it is easy to find the vector of the average time of the first gains in the balance:

$$[10{,}385 \quad 3{,}676 \quad 3{,}627 \quad 25{,}351] \quad (10)$$

Again, since the step is 20 years, the average time required for a randomly selected site to become a swamp is:

$$10{,}385 \times 20 = 208\,\textit{years} \quad (11)$$

o the transition to an area dominated by *Calluna vulgaris* species, forest or land with herbivores is on average '74, '73, 507 years.

Here, as in many other mathematical models, the basic properties of the model provide additional information about system sentiment being modelled and thus avoid unnecessary experimentation to determine the properties of empirical dynamics models.

Optimization models

It is very important for a professional in the environmental system to think about the applicability of models when working to solve a choice problem [11]. This unusual word 'optimisation' [8] is coined to refer to finding the maximum or minimum of a mathematical expression, or function, where we can change some variables within certain limits. If we only wanted to find the maximum, we could call this process maximisation – a word that is ultimately more acceptable. On the contrary, by finding only the minimum, we could use the word minimisation. Mathematically, one of these operations can always be transformed into the other, so that the two processes are treated as one and there is a certain logic to this. Almost all models can be used to determine some kind of maximum or minimum. Whether it makes sense to use them depends solely on the specific task at hand, but the situation arises quite often when it is necessary to examine whether it is possible to improve the productivity of an ecological system by changing the environment or changing management practices [15]. One of the main reasons for using models is that we need to be able to anticipate the results of these changes [3].

Using a dynamic model of, for example, yeast growth in mixed culture, described by differential equations, one can attempt to determine the ratio of initial amounts of the two-yeast species at which the yeast cells produce the maximum amount of yeast.

Once the basic parameters of the models have been determined experimentally, further experiments can be carried out to find the desired ratio that has been sustained on the models [4].

Optimal predator strategies

Suppose there is a predator at point *A* (the nest) and there are two potential food sources located in areas *B* and *C*. The time it takes to reach areas *B* and *C* and return to the nest (*A*) is two and three minutes respectively. On the other hand, in area B it takes the predator two minutes to catch his prey (X_1), while in area *C* it only takes him one minute to catch his prey (X_2). The energy value of X_1 extraction is estimated at 25 J, that of X_2 extraction at 30 J.

If we now introduce the constraint that the predator cannot spend more than 120 minutes a day travelling to and from any point and no more than 80 minutes a day searching for victims, then we arrive at the classical linear programming problem. These constraints are written as inequalities:

$$2X_1 + 3X_2 \leq 120 - \text{for relocating} \quad (12)$$

$$2X_1 + 1X_2 \leq 80 - \text{for finding food} \quad (13)$$

The implicit constraints $X_1 \geq 0$, $X_2 \geq 0$ must also be written, since the predator cannot catch a negative number of victims. Under these constraints we want to maximise the objective function:

$$Z = (25X_1 + 30X_2)J \quad (13)$$

This particular problem can easily be solved graphically, using the constraints written in the form of inequalities. The travel time limit shows that if X_1 is zero, then X_2 can be no more than 40 units. Similarly, if X_2 is zero, then X_1 can be no more than 60 units. The combination of critical values X_1 and X_2 can be represented as a connecting line between two points (Figure 1):

$$(X_1 = 60; X_2 = 0) \quad (14)$$

$$(X_1 = 0; X_2 = 40) \quad (15)$$

Applying similar reasoning to the food time constraints, we see that if X_1 is zero, then X_2 cannot be greater than 80 units, and if X_2 is zero, then it cannot be greater than 40 units.

Therefore, all the solutions that make sense are in the OPQR quadrangle (see Figure 1), and the maximum of the objective function is reached at the point furthest from the origin in the direction indicated by the arrow. This point has the coordinates (X_1=30; X_2=20) as the maximum value of the objective function:

$$Z = (25X_1 + 30X_2) = 1350\,J \quad (16)$$

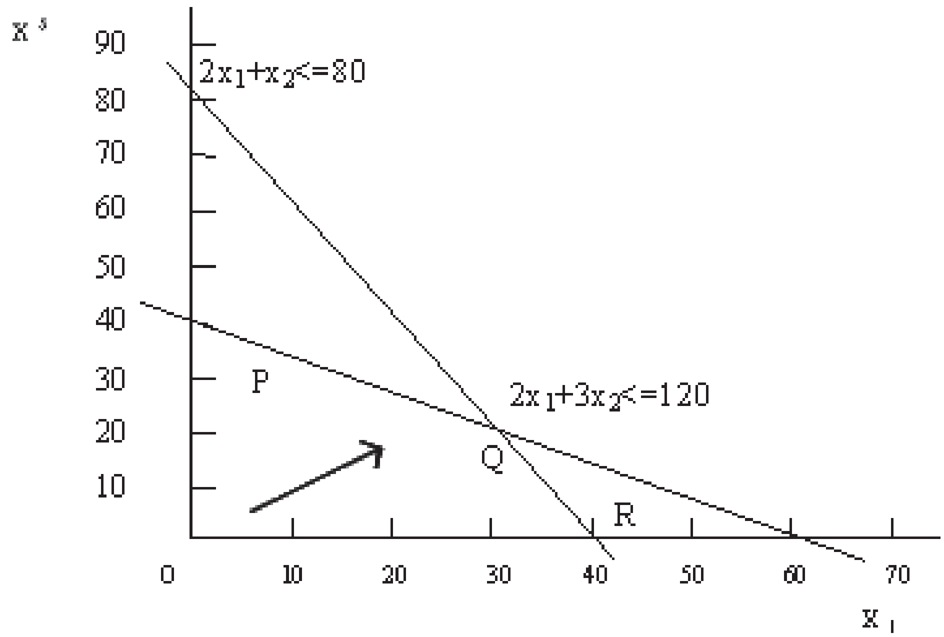

Figure 1. Graphical solution of a linear programme

You can check the effect of relaxing one or both constraints on the objective function, remembering that the most important thing in optimisation is to find the frequent constraint whose relaxation allows you to find an even better solution.

Conclusion

The problem of mathematical modelling of ecological systems is considered from a conceptual perspective. The fundamental properties of qualitative mathematical models of ecosystems are identified and analysed analytically. At the same time, real-world situations for applications require the design of simulation models, for which analytical methods are only possible, if at first, and for the final solution, numerical schemes should be used.

Natural objects are complex integrated systems. Their division into simple subsystems is done by abstracting from relatively weak interactions. Initially, mathematical modelling was used to study populations. As mathematical modelling techniques develop and knowledge of population ecology increases, the model improvises and becomes more complex, it becomes more adequate. The modelling is used to study animal and plant communities. With the development of computer technology, simulation models of complex ecosystems have begun to be developed.

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SAFETY ASSURANCE OF FIRE PREVENTION AND FIRE FIGHTING FOR INDUSTRIAL AREA, ECONOMIC ZONES, LESSONS LEARNED FROM VIETNAM

Abstract. Industrial development, especially modern industry for export, is the goal of each country in order to promote socio-economic development. In Vietnam too, planning for construction and development of industrial parks and economic zones is always concerned and focused. In particular, the work of ensuring fire prevention and fighting safety for industrial parks and economic zones is a matter that is regularly studied and discussed in order to find optimal solutions, contributing to limiting the causes and conditions leading to the occurrence of fire or explosion, and if there is a fire or explosion, promptly and effectively organize fire fighting without causing great damage to people and property. With these approaches, the article focuses on clarifying theoretical issues about ensuring fire safety in industrial area and economic zones; analyze and evaluate the actual situation of implementing this work in Vietnam; on that basis, draw lessons from experience in organizing the work of ensuring fire prevention and fighting safety for industrial area and economic zones in the new situation.

Keywords: ensuring fire prevention and fighting safety; industrial area; economic zones; Vietnam.

1. Make a problem

As of June 2021, Vietnam has 370 industrial zones have been established, including 328 industrial zones outside the zones, 34 industrial zones located in the economic zone of coastal, 8 industrial parks located in border-gate economic zones with a total natural land area of about 115.2 thousand ha. Of the 370 industrial parks that have been established, there are 284 industrial parks in operation with a total natural land area of about 84.2 thousand hectares, industrial land area of about 55.9 thousand hectares and 86 industrial parks is now in the process of construction with a total land area of about 31 thousand hectares of natural, industrial land reached about 17.5 thousand hectares. For economic zones, especially coastal economic zones, according to the master plan on development of coastal economic zones of Vietnam up to 2020 and vision to 2030 approved by the Prime Minister, including 19 economic zones coastal economy with a total area of about 871.5 thousand hectares (including the sea surface area), of which the land area is about 582.3 thousand hectares (accounting for about 1.75% of the country's land area) and 289.2 thousand hectares of sea surface. In which, 18 economic zones have been established with a total area of 857.6 thousand ha, the land area is about 568.4 thousand ha, 01 economic zone has not been established yet, which is Ninh Co economic zone, Nam Dinh province area 13,950 ha [1].

From the above data, it shows the strong development of industrial area and economic zones in Vietnam. With the good control of the Covid-19 epidemic, the construction planning and development of industrial area and economic zones in Vietnam has been attracting many foreign investors, which shows that, in the next time, the type of industrial area and economic zones will continue to be invested and developed, the number of establishments in industrial area and economic zones will increase more and more. In order to attract investment, ensuring the safety of fire prevention and fighting for industrial parks and economic zones has always been of great interest to Vietnam, thereby, making an important contribution to ensuring the stability of the country determination and sustainable development.

2. Theoretical framework

In Vietnam, the terms "Industrial Area", "Economic Zone" are clearly defined in legal documents, namely Decree No. 82/2018/ND-CP dated May 22, 2018 of the Government on the management of industrial area and economic zones.

Accordingly, "Industrial area is an area with definite geographical boundaries, specialized in manufacturing industrial goods and providing services for industrial production, established under the conditions, order and procedures specified Decree No. 82/2018/ND-CP. Industrial area include many different types, including: Export processing zones, supporting industrial area, ecological industrial area (hereinafter referred to as industrial area, unless there are separate regulations for each type of industrial area)" [8]. There are also a number of related concepts such as: An export processing zone is an industrial area specializing in the production of export goods, providing services for the production of export goods and export activities, established according to conditions, submitted to Orders and procedures applied to industrial area specified in Decree No. 82/2018/NĐ-CP. The export processing zone is separated from the outside area according to regulations applicable to non-tariff zones specified in the law on import and export tax; Supporting industrial area is an industrial area specializing in the production of supporting industry products and providing services for the production of supporting industry products. The rate of land area for investment projects in supporting industries to lease or sublease must be at least 60% of the leasable industrial land area of the industrial area. An eco-industrial area is an industrial area in which enterprises in the industrial area participate in cleaner production and efficient use of resources, have association and cooperation in production to carry out industrial symbiosis activities in order to improve economic, environmental and social efficiency of enterprises.

Also according to Decree No. 82/2018/NĐ-CP, economic zones are defined as follows: "An economic zone is an area with definite geographical boundaries, including many functional zones, established to fulfill the objectives of attracting investment, socio-economic development, and protecting national defense and security. Economic zones specified in this Decree include coastal economic zones and border gate economic zones (hereinafter referred to as Economic Zone, unless there are separate regulations for each type)" [8]. In addition, there are some related concepts such as: Coastal economic zone means an economic zone formed in the coastal area and in the vicinity of the coastal area, was established under the conditions, order and procedures specified in Decree 82/2018/NĐ-CP; Border gate economic zone means an economic zone formed in the land border area and the area adjacent to the land border area with an international border gate or main border gate and was established under the conditions, order and procedures specified in Decree No. 82/2018/ND-CP. The above concepts are researched, developed and promulgated in legal documents showing the concern of the state, of the Government for industrial area and economic zones. In addition, giving specific and clear definitions of "industrial area and economic zones" created favorable conditions for all levels and branches in identifying, planning and developing industrial area and economic zones. At the same time, the planning for construction and development of industrial area and economic zones in Vietnam is carried out in accordance with the order and procedures prescribed by law.

Fire prevention and fighting is a field of activities directly related to ensuring social order and safety.

Although fire prevention and fighting activities are two concepts with different connotations, they are closely related, creating a unified whole in proactively preventing fire and explosion and being ready to extinguish fires. Therefore, it is possible to generalize about fire prevention and fighting as: Synthesis of organizational, technical and technological measures and solutions to eliminate or limit the causes and conditions of fire; is the combination of people and means in the application of methods, tactics, to save lives, save property, prevent the spread and extinguish fires in a timely and effective manner [9]. Thus, in essence, ensuring safety in terms of fire prevention and fighting is the application of organizational, technical and technological measures and solutions to eliminate and limit the causes and conditions of fire; at the same time, if there is a fire, organize the fire fighting promptly and effectively. From the above arguments, analysis and approaches, the following definitions can be drawn: "*Safety assurance of fire prevention and fighting for industrial area and economic zones is the application of organizational and technical measures and solutions of a competent person or state agency for industrial area and economic zones to eliminate and limit the causes and conditions of fire and if there is a fire, organize to save people, save property, prevent the spread and extinguish the fire promptly and effectively*". The application of organizational and technical measures and solutions for fire prevention and fighting in general and for industrial area and economic zones specified by law in Vietnam in legal documents on fire prevention and fighting such as: Law on fire prevention and fighting 2001 [11]; Law amending and supplementing a number of articles of Law on fire prevention and fighting 2013 [12]; Decree No. 136/2020/ND-CP dated November 24, 2020 of the Government detailing a number of articles and measures to implement the Law on Fire Prevention and Fighting and the Law amending and supplementing a number of articles of the Law on fire prevention and fighting [6]; Circular No. 149/2020/TT-BCA dated December 31, 2020 of the Ministry of Public Security detailing a number of articles and measures to implement the Law on Fire Prevention and Fighting and the Law amending and supplementing a number of articles of the Law on fire prevention and fighting and Decree No. 136/2020/ND-CP dated November 24, 2020 [2]; Circular No. 139/2020/TT-BCA dated December 23, 2020 of the Ministry of Public Security Regulations on standing ready work for fire fighting and rescue and rescue of the People's Public Security force [3]; Circular No. 140/2020/TT-BCA dated December 23, 2020 of the Ministry of Public Security Regulations on implementation of fire fighting and rescue activities of the People's Public Security force [4]; Circular No. 141/2020/TT-BCA dated December 23, 2020 of the Ministry of Public Security Regulations on inspection of fire prevention, fighting and rescue of the People's Public Security force [5]; … Besides the system of legal documents, in Vietnam to ensure the safety of fire prevention and fighting in general and in industrial area and economic zones in particular, there is also a system of national technical standards and regulations in the field of fire prevention and fighting, typical: QCVN06:2021/BXD National technical regulations on fire safety for buildings and constructions [13]; QCVN05:2020/BCT National technical regulation on safety in production, commerce, use, storage and transportation of hazardous chemicals [14]; QCVN01:2019/BCA National technical system on Fire fighting and prevention apparatus and equipment for storage, delivery port and distribution stations of gas [15]; TCVN9358:2012 Installation of equipment earthing system for industrial projects – General requirements [10]; … For the promulgation and application of national technical standards and regulations related to the field of fire prevention and fighting in Vietnam, The Law on Fire Prevention and Fighting has been specifically defined in Article 8, as follows: "Fire prevention and fighting activities must comply with national technical regulations; Competent state agencies shall promulgate technical regulations after reaching agreement with the Ministry of Public Security on regulations on fire prevention and fighting; Competent agencies and organizations develop and publicize national standards and basic standards on fire prevention and fighting after reaching agreement with the Ministry of Public Security; Application of Vietnamese standards on fire prevention and fighting: National standards on fire prevention and fighting are compulsory; Standards on fire prevention and fighting must be consistent with national technical regulations on fire prevention and fighting; Ensuring the uniformity and feasibility of the applied standard system. Foreign standards and international standards on fire prevention and fighting shall be applied in Vietnam in the following cases: Foreign standards and international standards specified in international treaties to which Vietnam is a contracting party; Foreign standards, international standards have higher safety regulations on fire prevention and fighting than Vietnamese standards or in accordance with the actual requirements of Vietnam and approved in writing by the Ministry of Public Security. For requirements on fire prevention and fighting without technical standards and regulations, the guidance of competent state management agencies in charge of fire prevention and fighting shall be followed" [12].

Thus, basically, the legal system of fire prevention and fighting has met the organization and implementation of fire prevention and fighting safety for industrial parks and economic zones in Vietnam today. The problem is the organization and management of competent state agencies, the performance of fire prevention and fighting responsibilities of the head of the facility as well as awareness and observance of rules and regulations on fire prevention and fighting of employees working in industrial area and economic zones.

3. Practicality

Currently, the management, guidance and implementation organization the provisions of the law in the work of ensuring the safety of fire prevention and fighting for industrial area and economic zones in Vietnam mainly decentralized to the Police Department for fire prevention and fighting and rescue and rescue of the provincial police, this is the core unit in the implementation of fire prevention and fighting in each locality in Vietnam. Grasp the position, role and significance of the work of ensuring safety in fire prevention and fighting in general and for industrial area, economic zones in particular, police force for fire prevention and fighting and rescue and rescue in Vietnam actively advised the Government and the Ministry of Public Security to promulgate systems of legal documents, national technical standards and regulations in the field of fire prevention and fighting; In addition, in the process of implementation, based on the specific actual situation, actively advised the Secretariat to issue Directive No. 47-CT/TW dated June 25, 2015 of the Secretariat on strengthening the Party's leadership in fire prevention and fighting, Resolution No. 99/2019/QH14 dated November 27, 2019 of the National Assembly on continuing to improve and improve the effectiveness and efficiency of the implementation of policies and laws on fire prevention and fighting and Decision No. 630/QD-TTg dated 11/5/2020 of the Government promulgate a plan to implement the Resolution of the National Assembly on continuing to improve and improve the effectiveness and efficiency of the implementation of policies and laws on fire prevention and fighting; Plan No. 134/KH-BCA-C07 on April 17, 2019 Fire prevention and fighting inspection plan for establishments in industrial area and production establishments, onion warehouses with high risk of fire and explosion in residential areas; ... Thereby, promptly rectified, provided measures and solutions to overcome difficulties and problems in the process of implementing the provisions of the law, standards and national technical regulations on fire prevention and fighting in general and for industrial zones and economic zones in particular.

In 2020, under the influence of the Covid 19 pandemic, the socio-economic situation of the world and Vietnam has been affected by many impacts, has affected the investment and development of industrial area and economic zones. However, with the fierceness of the whole political system, the consensus and consensus of the Vietnamese people, the situation of the Covid-19 epidemic in Vietnam is basically under control, people are stable and take measures to prevent and control the epidemic according to the guidance of the Ministry of Health of Vietnam. Accordingly, the work of ensuring the safety of fire prevention and fighting for industrial parks and economic zones has also been affected, Fire and explosion prevention activities that were previously carried out in person are now being implemented online. According to statistics of the Police Department of Fire Prevention and Fighting and Rescue, Ministry of Public Security of Vietnam, year 2020, has closely coordinated with information and communication agencies, departments, branches and local authorities to promote propaganda, built and broadcast 5,523 reportages; 8,734 news articles; hang 43,888 banners; issued 52,402,190 leaflets, documents and recommendations; itinerant propaganda 7,616 turns; organized 36,118 oral propaganda sessions attracting 1,656,843 listeners. Organized professional training with 13,646 classes with 522,953 turns of trainees, granted 414,643 professional training certificates. Consolidating 18,1060 grassroots, civil defense and specialized fire prevention and fighting teams with a total of 171,857 members; building 5,289 grassroots, civil defense and specialized fire prevention and fighting teams with 49,105 members [7]. Thereby awareness of fire prevention and fighting of heads of agencies, organizations or agencies managing industrial area and economic zones There have been significant changes and improvements. The implementation of safety inspection on fire prevention and fighting is strictly carried out in accordance with the prescribed order and procedures. Also in 2020, the police force of fire prevention and fighting and rescue and rescue of local police an organize fire safety inspection of 305,983 establishments, make 305,983 inspection minutes; recommendations to overcome 256,262 existing and shortcomings in fire prevention and fighting. Making 15,953 records of administrative violations, sanctioning administrative violations 15,953 cases with a total fine of 61,148 billion VND; temporary suspension of 522 cases; suspended operations 521 cases. The Police Department of Fire Prevention, Fighting and Rescue, Ministry of Public Security of Vietnam directly sanctioned 28 administrative violations with a total fine of 2,273 billion VND. The inspection results showed that most of the inspected establishments existed and violated, mainly concentrated in establishments that have been in operation for a long time; … [7]. With the efforts and results achieved in the implementation of fire prevention and fighting safety in general and for industrial area, economic zones in particular has played an important role in stabilizing social security, promote sustainable socio-economic development of the country.

4. Lessons learned

Facing difficulties and challenges from climate change, from the Covid 19 Pandemic to continue to maintain the table to ensure the country's socio-economic sustainable development, in which, stabilizing and sustainably developing industrial area and economic zones is the top important goal that needs to be done in parallel with responding to actual situations. In order to successfully achieve the above goal, through the research, the author draws some lessons from Vietnam in ensuring fire safety in industrial area and economic zones as follows:

– System of legal documents, standards and technical regulations on fire prevention and fighting related to the assurance of fire prevention and fighting safety in industrial area and economic zones should be fully and practicable. This is an important legal basis for state management agencies in charge of fire prevention and fighting to effectively perform their functions and tasks, at the same time, it is also a basis for heads of establishments to organize activities to ensure fire prevention and fighting safety for industrial parks and economic zones under their management. Besides, in order to ensure the feasibility in implementing implementation, regulations of laws, standards and technical regulations in the field of fire prevention and fighting need to be regularly reviewed, propose amendments to suit the actual situation, meet the development requirements in each period, each stage of the development of industrial area and economic zones.

– It is necessary to involve the whole political system in leading, directing, promulgating and organizing the implementation of the provisions of the law on fire prevention and fighting for industrial area and economic zones. The timely attention, leadership and direction of the political system will make an important contribution, promptly solve difficulties and problems in organizing the implementation of fire prevention and fighting safety for industrial area and economic zones.

– Ensure the assignment and decentralization in the organization to ensure the safety of fire prevention and fighting for industrial area and economic zones clearly and specifically, do not overlap. The same goes for state management agencies and industrial area and economic zones, it is necessary to strictly follow this principle, because the assignment and decentralization will be associated with responsibilities, rights and obligations to perform, the overlap in management will lead to the dislocation of responsibility for implementation, thereby leading to the effective organization and implementation of fire prevention and fighting safety for industrial area and economic zones, which did not bring the desired effect. On the contrary, the clear and specific assignment and decentralization will motivate the individuals and organizations assigned to be serious in organizing the implementation as well as closely coordinate with each other in organizing the implementation of fire prevention and fighting safety for industrial parks and economic zones.

– Focus on developing and organizing the effective implementation of the four on-the-spot motto in industrial area and economic zones, which are: "Command on the spot; Force in place: including all employees working in industrial area, economic zones, whose core is the grassroots fire prevention and fighting force; On-the-spot means: means the ready-made means for the work of saving people and property; water sources and fire fighting materials include: sand, water, fire extinguishers, fire trucks; On-site supplies and logistics: Availability of funding; necessary necessities for fire prevention, fighting and rescue work". In fact, all activities, if detected in time and handled quickly, will minimize the consequences and damage caused.

– State management agencies in charge of fire prevention and fighting, the core force is the police force for fire prevention and fighting and rescue, which needs to be proactive in organizing and implementing its tasks; at the same time, guide the Management Board of industrial area and economic zones and the heads of establishments to organize fire prevention and fighting activities by themselves in accordance with the provisions of law. Proactive, creative and flexible in applying measures to implement the provisions of the law to the subjects under management. In addition, for violations of the law on fire prevention and fighting, it is necessary to strictly handle and take timely remedial measures.

– Effectively apply scientific, technical and technological achievements of the fourth industrial revolution to the work of ensuring fire prevention and fighting safety for industrial area and economic zones. Research and apply scientific and technological achievements of the 4.0 industrial revolution in implementing basic investigations on fire prevention and fighting, for example, exploiting achievements from Big Data in storing, analyzing data and data collected from basic business activities; exploiting artificial intelligence (AI) in basic investigation, information collection for industrial area, economic zones, etc. which is difficult for humans to observe or directly perform; besides, fire alarm, early fire warning equipment, equipment for intelligent and modern fire fighting and rescue; modern monitoring and positioning system; … the development of digital technology, if fully exploited, science can be said to be one of the great opportunities, an effective support tool in ensuring the safety of fire prevention and fighting for industrial area and economic zones.

– Regularly and periodically organize preliminary and final reviews to evaluate and learn from experience in the process of organizing and implementing the work of ensuring the safety of fire prevention and fighting for industrial parks and economic zones in response to requirements and tasks set out in the new situation. Preliminary and summary results should be summarized and proposed to competent state agencies to issue leadership and direction documents to deal with difficulties and problems in the implementation process, since then, the implementation of fire prevention and fighting safety for industrial area and economic zones will be more convenient and effective.

5. Conclusion

It can be affirmed, learning and exchanging experiences in general and experience in ensuring safety in fire prevention and fighting for industrial parks and economic zones of great significance. Each country has different political system, characteristics of operation, exploitation, establishment of industrial area, economic zones are different, therefore, the experience through research and synthesis from the above theory and practice, when applied, needs to be researched and taken into account the actual situation of each country, If so, the organization and implementation of fire prevention and fighting safety for industrial area and economic zones will really bring efficiency.

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Contents