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Ecologo-Biological Estimation of Soils under Vegetable Cultures as the Indicator Fertility of Soils[#]

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In Irragic gypsic calsisols (in WRB), in Irragic calsisols (in WRB), in Irragic mollic luvisols (in WRB) and in Irragic gleyic luvisols (in WRB) of subtropic zones in a crop rotation under vegetable cultures, at permanent cultivation of these cultures and virgin variants for comparison it is investigated fermentativ activity, number of microorganisms, intensity of carbonic gas isolation from soils, nitrification, ammonification and decomposition of cellulose. On the basis of biochemical parameters are given biodiagnostics and a complex of biological parameters are given the integrated parameter of ecologo-biological condition of investigated soils is determined. Results of analyses have shown, that using of the scientifically-grounded crop rotations in conditions of in Irragic mollic luvisols and in Irragic gleyic luvisols irrigation it is possible to keep fertility, and it also possible to increase it in Irragic gypsic calsisols and Irragic calsisols.

Key words: vegetable cultures, permanent cultivation, biochemical parameters, biodiagnostica, integral parameter of ecologo-biological condition of soils.

Introduction

For anthropogenous influence on natural ecosystem the strongest change undergoes first of all biotic components. Now the man's activity became powerful pedogenic factor in the agricultural landscapes. For agricultural development of natural landscapes, especially, for ploughing soils, there is decrease of fermentative activity. The further evolution of the level fermentative activity depends on character of soils use (Khaziyev, 1982). For the decision of a problem of the expanded reproduction of fertility of irrigated soils special attention deserve the investigations of biological processes of substances transformation, directed the regulation which promotes increase of productivity and preservation of soil fertility. Biological properties of soils are important parameters of soil fertility. As the estimation of the biological activity of soils is close to an estimation of the fertility level, it enables to recommend a parameter of the general biological activity for a large use at monitoring and soil bioindication, including, for studying of anthropogenous influences (Kolesnikov *et al.,* 2000). One of the important parameters of intensity and orientation of biological processes in soil is activity of soil enzymes. The observation of the orientation of dynamics (changes) of fermentative activity gets great value in diagnostics, forecasting and prevention (warning) of the negative changes biological conditions of reclaimed soils for the preservation of their bioproductivity (Agafarova, *et al.,* 2000).

Replacing natural biocoenosis by cultural agrocenosis, a man breaks developed dynamic balance between soil and plant. The man's activity directed only to increase of economic productivity of the separate, cultures of agrocenosis, often results in negative consequences. Thus, in view of the aforesaid, a great interest is represented to comparative studying a crop rotation and permanent crops that will allow understanding more deeply and more full value of crop rotations in increase of soil fertility and getting high crops. However, the change enzymatic activity of soil in a crop rotation and for permanent growing is not always unidirectional. Change of cultures in a crop rotation should be considered as a change biofouling in agrosystem (soils - microorganisms - plants -an atmosphere) in time. The amplitude of change of soil enzymes activity in soil for permanent crop is much higher than in fields of a crop rotation, i.e. annual alternation of cultures with the different influence on soil, results in some alignment of intensity of biochemical processes. Therefore in conditions of crop rotation the difference of the plant influence on fermentative activity of soil is not revealed so brightly, as for permanent cultivation of cultures, mainly because of unequal after-effect various predecessors. It is necessary to note, that dynamics of activity of different enzymes for irrigation is not unequal. The

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irrigation renders not only a positive effect on fermentative activity in itself, but it is one of the effective methods of the influence on fermentative activity. The biochemical activity of soils under cultures of a crop rotation and in permanent crops was unequal. Thus, plants, as a whole rendering complex influence on soil and on biochemical process proceeding in it change fermentative potential, mainly raising it. The cultivation of the agricultural plants in the system of cultures alternation or permanent crops essentially affects on soil biological activity.

Object of researches

Object of researches are grey-brown and gray-meadow soils of dry subtropic, alluvial meadow-forestry soils of semi-arid subtropic and yellowish-clayey soils of moderate-humid subtropic zones.

Irrigative grey-brown soils (in WRB - Irragic gypsic calsisols)**.** Grey-brown soils are formed in a result of centuriesold activity of the Caspian Sea. The climatic conditions are distinguished by enough quantity of heat and long vegetative period for the cultivation of agricultural plants in open ground in irrigation conditions. In irrigative grey-brown soils humus maintenance forms 1.5-1.9%, reaction of the soil environment is weakalkaline (8.3-8.5), saline soil (chloride-sulphate).

Irrigative meadow-serozem soils (in WRB-Irragic calsisols). The essential importance in genesis of meadow-serozem soils signifies hydrological conditions of the territory, in particular the level and regime of ground waters, the duration and intensity of artificial irrigation. In morphological structure of meadow-serozem irrigative soils the sings of salinity and gleyzation are often met. The arable horizon maintains 1.3-2.8 % of humus with the natural increase from new irrigated weak-cultural till oazis-irrigative highcultural ones. In weakcultural versions, from the depth of 30-40 sm maintenance of the change Na increases and on the phone of intensified alkalinity promote solonetzity of these soils.

Irrigative meadow-forestry soils (in WRB - Irragic mollic luvisols). Alluvial-meadow-forestry soils of semi-arid subtropic zones are characterized by moderate-heat subtropic climate. In irrigative alluvial-meadow-forestry soils the humus maintenance forms 3,0-3,5 %, of carbonation, on the whole profile, reaction of soil environment – weakalkaline (8.0-8.4), saline soil is observed.

Irrigative yellowish-glayey soils (in WRB-Irragic gleyey luvisols). Yellowish-glayey soils of moderate-humid subtropic zones are formed under the influence of variable humid subtropic climate. The climate of subtropic zones with superfluous moisture in spring and autumn periods and insufficient - in summer. Humus maintenance forms 2.5-5.0% in irrigated yellowish-glayey soils of upper horizons, the reaction of soil environment is acid (water 5.5-6.5, salty 5.0-5.5), uncarbonatic.

The study of the influence of crop rotation and permanent separate agricultural plants cultivation on biological activity was carried out in irrigative grey-brown soils, in six-full vegetable-fodder (1 field - lucerne of the first year of using; 2 field - lucerne of the second year of usage; 3 field - water-melon; 4 field - potato; 5 field - garlic; 6 field - white head cabbege +tomato) and in five-full vegetable-bean crop rotations (1 field - tomato; 2 field - bean; 3 field - water-melon; 4 field - potato; 5 field - bean); in meadow-serozem soils, in four-full vegetable-fodder crop rotation (1 field - lucerne of the first year of using; 2 field - lucerne of the second year of usage; 3 field - cucumber; 4 field-tomato); in alluvial-meadow-foresty soils, in six-full vegetable-fodder crop rotation (1 field - lucerne of the first year of using; 2 field - lucerne of the second year of usage; 3 field - onion; 4 field - cucumber; 5 field - white head cabbage; 6 field - green grass+tomato); in irrigative yellowish-glayey soils in five-full vegetable-bean crop rotation (1 field - tomato; 2 field - white head cabbage+masize for silage; 3 field – onion; 4 field - bean; 5 field - bean).

Vegetable cultures which left in a crop rotation raised stretch.

Materials and Methods

Activity of ferments by F.X.Xaziyev, nitrification ability of soils by N.I.Bolotina, E.N.Abramova, ammonification ability of soils by E.Z.Tepper, V.K.Shilnikov, G.N.Pereverzev, secretion of carbonic gas from soils by B.N.Macarov, decomposition of cellulose by I.S.Vostrov, A.N.Petrova, quantity of microorganisms by the standard method (an general number of microorganisms, actinomycetes and microscopic fungus – for the method of Microbiological Institute of USSR - Moscow) has been determined. All analyses were carried out in 3-fold frequency. The received data were exposed to mathematic-statistical processing on 95%-s' significance value by the standard technique. Biological activity of irrigated soils under vegetable in crop rotation was determined by us and it is permanent.

For association of a plenty of biological parameters the technique of definition of an integral parameter of a biological condition of soils (IPBCS) (Kazeyev et al. 2004) has been developed. For this purpose in sample the maximal value of each of parameters is accepted for 100 % and in relation to it value of the same parameter in other samples is in percentage expressed.

$$B_1 = (B_x/B_{max}) * 100, \qquad (1)$$

Where B_1- a relative point of a parameter, B_x - actual value of a parameter, B_{max} - the maximal value of a parameter.

After that, relative values of many parameters are summarized. Their absolute values are cannot be summarized, as have different units of measurements.

$$B_{av}=(B_1+B_2+B_3+\ldots\ldots B_n)/N, \qquad (2)$$

Where B_{av} - an average estimated point of parameters, N - number of parameters. An integrated parameter of a biological condition of ground expect similarly to the formula (1):

$$IPBCS = (B_{av}/ B_{av.\ max})*100, \qquad (3)$$

Where B_{av} - an average estimated point of all parameters, $B_{av.\ max}$ - the maximal estimated point of all parameters.

Results and Discussions

Activity of invertase, urease, phosphatase from hydrolytic enzymes, catalase and dehydrogenase from oxidation-reduction have been investigated by us.

Invertase – Among the studied variants in the irrigated grey-brown, gray-meadow and irrigated meadow-forestry soils the highest activity of invertase during vegetative period was under lucerne of the first and second year of the use, in irrigated yellowish-clayey soils under a bean. Results of the investigation showed that the best biological activity in conditions of irrigation from the studied enzymes possesses yellowish-clayey. The biological activity of the studied soils decreases in the following line: yellowish-clayey >irrigated grey-brown >irrigated meadow-forestry >gray-meadow.

Urease – From all the investigated soils the lowest urease activity is characteristic for yellowish-clayey, grey-brown and gray-meadow soils, the high activity is noted in the irrigated meadow-forestry soils.

Phosphatase - Phosphatase activity on the average sizes as compared with invertase and urease, in the lesser degree renders the dependence from cultivated cultures and ecological factors. Phosphatase activity is higher in the irrigated yellowish-clayey, in the gray-meadow and in the irrigated gray-brown soils, is lower in the meadow-forestry soils.

Dehydrogenase – Studying of dehydrogenase activity of irrigated soils has shown that the activity of this enzyme depending on soil type and biological features of the cultivated cultures changes in dynamics. The highest dehydrogenase activity has shown yellowish-clayey soils. Apparently, an anaerobe condition in the yellowish-clayey soils is positively influenced on dehydrogenase activity.

Catalase - Catalase activity of the investigated soils under cultivated cultures changes in dynamics. The researches showed that the highest activity of catalase is observed in irrigated grey-brown soils, but is the least in the irrigated yellowish-clayey soils. Apparently, the acidity of the soil environment in irrigated yellowish-clayey soils is negative, has affected on catalase activity.

So, results showed that the activity of hydrolytic ferments as compared with oxidation-reduction enzymes less changing and it is determined vegetations of the cultivated cultures. Oxidation-reduction processes more dynamical and quickly reacts to the changes of ecological conditions. The results of analyses show that the ferment activity in dependence of plant biology, phases of the plants development, soil - ecological condition, soil type vibrate in wide ranges. The highest activity of the soil enzymes is noted in the phases of the plant active development, at the end of the vegetation with the beginning of disintegration of the root remains. As a result of investigations it is established that the enzymes activity non-uniformly decreases downwards on a soil structure. However, the change of the fermentative activity of soils in a crop rotation and for permanent cultivation is not always unidirectional. It depends on biological features of the concrete cultures, used agrotechnics, fertilizer systems, features of attitude of individual enzymes to changing conditions and on soil peculiarities, on their cultivated degree.

Nitrification ability - Nitrification ability of irrigated soils under vegetable cultures in a crop rotation and at permanent cultivation of these cultures has been determined. Activity of nitrification was higher in gray-brown soils under cultivated cultures, but low - in irrigated yellowish-clayey soils.

Ammonification ability - Ammonification ability of investigated soils was high in irrigated yellowish-clayey soils. Ammonification ability of investigated soils decreases in the following line: irrigated yellowish-clayey -> meadow forestry > gray-meadow > gray-brown.

Secretion of carbonic gas - The highest quantity of secretion of carbonic gas was comparatively observed in yellowish-clayey soils. Intensity of secretion of carbonic gas from ground was high in a crop rotation, rather than at permanent cultivation of these cultures.

Decomposition of cellulose - Intensity of decomposition of cellulose was low in irrigated gray-brown soils. Intensity of decomposition of cellulose in investigated soils decreases in the following line: irrigated yellowish-clayey > meadow-forestry > gray-meadow > gray-brown.

Microorganisms - Influence of organic substances on quantity and a biomass of microorganisms are investigated by many authors (EkberliI, *et al.,* 2005; Ozdemir, *et al.,* 2000; Suruju *et al.,* 1998).

The general number of microorganisms in irrigated soils under cultivated cultures gradually decreases with the reduction of organic substance depending on depth. The general number of bacteria is changed depending on humus horizon. In irrigated soils the greatest quantity of microorganisms was in a crop rotation under lucerne, a bean, and the least at permanent cultivation of these cultures under an onions and garlic. The most widely submitted ammonificators are from different groups of soil microorganisms in irrigated soils. Gray soils and gray-brown ground in comparison with meadow-forestry and yellowish-clayey soils, the richman are populated bacillar with forms and actinomyces. Number of microscopic fungus in researched soils is not high. Number fungus in comparison is maximal in yellowish-clayey soils.

On the basis of biological parameters biodiagnostics irrigated gray-brown, gray-meadow, meadow forestry and yellowish-clayey soils is given in a crop rotation, at permanent cultivation of these cultures and their analogues of virgin soils (table 1). Biodiagnostics of irrigated gray-brown, gray-meadow, meadow forestry and yellowish-clayey soils is given in a number of works (Orujova, 2005a; 2006a; 2007a, 2006b).

For an estimation of the irrigation influence on biological activity of soils the methodology has been used by us. The main principles of the developed methodology and methods of the investigations and an estimation of ecology-biological condition of soils are stated in a number of soils (Kazeev *et al.,* 2004). The biological activity of soils should be examined as soil property derivative sets abiotic, biotic and anthropogen factors of the soil-forming. The anthropogen influence affects on soil forming and biological activity (irrigation, soil processing, fertilizer bringing, and a crop rotation). Now there is no one universal method of the definition of the biological activity of soils and not enough parameter for its estimation. The authors on values of the most informative parameters of the biological condition of soils recommend an integrated parameter of an ecology-biological condition of soil (Kazeev *et al.,* 2004). The given methodic allows to estimate the set of biological parameters. For an estimation of the soil ecology-biological condition the authors have developed main principles of the methodology and methods of the investigations (Valkov *et al.,* 1999). In the basis of the investigation methodology and estimation of the ecology-biological conditions of soils, on the basis of biological activity of soil it was put systematic approach to studying objects. The estimation of soil biological activity is close to an estimation of the fertility level. On change of the biological activity of soils it is possible to judge about its fertility. It gives change to recommend an integrated parameter of the biological condition for a large use monitoring and bioindication of soils, including for studying of anthropogen influence (Kazeev *et al.,* 2004).

On the basis of fermentative activity of soils the integrated parameter of the soil ecology-biological condition has been determined by us (Orujova, 2005b; 2007a, 2007b). The results of analyses on biological activity showed that the activity of irrigated grey-brown soils under lucerne was high, but under garlic is the least. The other cultures on ferment activity occupy intermediate position. The ecology-biological estimation of irrigated grey-brown and gray- meadow soils in a crop rotation under cultivated cultures vibrated in the limits of 63-100 %, but permanent cultivation of these cultures of 39-68 % (table 2). From the table it is visible, that the integrated parameter of ecology-biological condition of the irrigated gray-meadow soils in a crop rotation and permanent cultivation of these cultures vibrated in limits of 39-100%, in meadow-forestry soils accordingly changed in 70-100% interval. This parameter as compared with permanent (47-57%) cultivation of these cultures in a crop rotation (70-100%) on 23-43% was higher. The ecology-biological estimation of irrigated yellowish-clayey soils showed that this parameter was highest under a vegetable string bean, the least under an onion and other cultures occupied intermediate position. In irrigated yellowish-clayey soils this parameter in a crop rotation under cultivated plants vibrated in limits of 71-100%, but 50-79% is permanent.

Conclusion

- The ecology-biological estimation of irrigated grey-brown and gray- meadow soils in a crop rotation under cultivated cultures vibrated in the limits of 63-100 %, but permanent cultivation of these cultures of 39-68 %.
- Integrated parameter of ecology-biological condition of the irrigated gray-meadow soils in a crop rotation and permanent cultivation of these cultures vibrated in limits of 39-100%, but in irrigated meadow-forestry soils 47-100%.
- In irrigated yellowish-clayey soils this parameter in a crop rotation under cultivated plants vibrated in limits of 71-100%, but 50-79% are permanent.
- The results of analyses have shown, that an ecology-biological estimation of irrigated soils under lucerne, vegetable string is high, under an onion and garlic is the least and other cultures occupied intermediate position. This parameter in a crop rotation in 40-50% is higher than permanent cultivation of these cultures.

Table 1. Biodiacnostika of soils of subtropical zone

№ field Culrura	inver taza., mg of glucose	urease, mg NH_3	phos-phatase, mg P_2O_5	cata-lase, sm^3 O_2	dehydro-genase, mg TFF	nitrifi-cation, N-NO3 mg/kg	ammoni-fication, $N-NH_3$ mg /kg	CO_2/ kg/ha· hour	Intensive decom sellulos . %	microor-ganisms hund/gr
Dry subtropic zone - Grey-brown soils (I scheme – six-full vegetable-fodder crop rotation)										
Virgin soils	11,40	4,10	1,91	10,8	4,38	46,8	17,8	2,50	8,4	1318
Rotation- I the schema	11,77	3,14	2,65	13,2	6,08	65,1	21,2	3,36	10,3	2157
Permanent	8,97	2,20	1,55	8,7	3,48	34,2	14,8	2,74	7,7	1214
Dry subtropic zone - Grey-brown soils (II scheme - five-full vegetable-bean crop rotation)										
Virgin soils	11,40	4,10	1,91	10,8	4,38	46,8	17,8	2,50	8,4	1318
Rotation- II the schema	11,24	3,09	2,70	12,3	5,71	55,6	20,4	3,32	10,0	1822
Permanent	8,97	2,20	1,55	8,7	3,48	34,2	14,8	2,74	7,7	1214
Dry subtropic zone - Meadow-serozem soils (four-full vegetable-fodder crop rotation)										
Virgin soils	12,8	5,60	1,48	6,2	6,75	25,7	50,4	4,90	17,4	2836
Rotation	9,69	4,24	0,93	7,1	4,88	31,2	35,6	3,39	19,5	3661
Permanent	6,64	3,03	0,48	5,6	2,81	16,5	23,3	2,80	13,9	2617
Semi-arid subtropic zone - Alluvial-meadow-forestry soils (six-full vegetable-fodder crop rotation)										
Virgin soils	12,8	5,60	1,48	6,2	6,75	25,7	50,4	4,90	17,4	2836
Rotation	9,69	4,24	0,93	7,1	4,88	31,2	35,6	3,39	19,5	3661
Permanent	6,64	3,03	0,48	5,6	2,81	16,5	23,3	2,80	13,9	2617
Moderate-humid subtropic zone - Yellowish-gleyey soils (five-full vegetable-bean crop rotation)										
Virgin soils	13,7	3,8	2,86	4,5	16,03	23,9	132,8	8,40	29,5	2869
Rotation	12,6	3,39	2,30	4,9	14,08	26,7	118,1	6,07	23,9	3185
Permanent	10,3	2,72	1,22	3,6	11,46	15,5	101,4	5,06	19,9	2718

The table 2. Integrated parameter of a ecology-biological condition of irrigated soils - IPEBC (0-50 sm), % from a poppy

№ fields Cultures	invertaza., mg of glucose	urease, mg NH_3	phos-phatase, mg P_2O_5	catalase, sm^3 O_2	dehydro-genase, mg TFF	IPEBC, %
1	2	3	4	5	6	7
Dry subtropic zone - Grey-brown soils (I scheme – six-full vegetable-fodder crop rotation)						
I year lucerne	87	85	82	88	79	81
II year lucerne	100	100	100	100	100	100
III water-melon	88	85	86	87	77	85
IV a potato	87	85	88	84	65	82
V a garlic	62	70	53	69	57	63
VI a tomato+ winter cabbage	87	85	88	84	65	82
Dry subtropic zone - Grey-brown soils (II scheme - five-full vegetable-bean crop rotation)						
I a potato	69	72	62	70	48	64
II a bean	89	96	95	86	76	88
III a water-melon	78	83	77	71	69	76
IV a tomato	74	77	86	74	66	75
V a bean	89	92	96	91	76	89
Permanent (gray-brown soils)						
Tomato	63	52	44	58	44	40
Water-melon	58	51	36	49	36	46
Potato	60	54	40	54	29	47
Garlic	52	45	24	49	30	40
Winter cabbage	74	73	60	56	49	62
Bean	73	74	68	65	60	68
Dry subtropic zone - Meadow-serozem soils (four-full vegetable-fodder crop rotation)						
I year lucerne	89	86	73	84	94	85
II year lucerne	100	100	100	100	100	100
III a cucumber	87	71	39	79	96	74
IV a tomato	87	63	33	76	88	69
Permanent (gray- meadow soils)						
Tomato	70	45	12	51	65	49
Cucumber	61	38	9	40	47	39
Semi-arid subtropic zone - Alluvial-meadow-forestry soils (six-full vegetable-fodder crop rotation)						
I year lucerne	82	89	82	84	88	85
II year lucerne	100	100	100	100	100	100
III an onions	75	75	43	74	82	70
I a cucumber	75	72	59	81	67	71
V a winter cabbage	88	79	63	83	85	80
VI a tomato	95	79	65	100	91	86
Continuation of the table 2 (meadow-forestry soils)						
Cucumber	56	56	39	69	45	53
Winter cabbage	62	58	35	70	54	56
Tomato	57	55	43	73	57	57
Onions	49	62	23	64	36	47
Moderate-humid subtropic zone - Yellowish-gleyey soils (five-full vegetable-bean crop rotation)						
1	2	3	4	5	6	7
I a tomato	96	82	73	69	92	82
II a winter cabbage + corn	99	83	90	85	96	91
III onions	80	73	63	63	74	71
IV string bean	100	100	100	100	100	100
V string bean	99	99	97	94	99	85

Permanent (yellowish-clayey)

1	2	3	4	5	6	7
Tomato	81	71	47	54	80	67
Winter cabbage	75	63	40	71	71	64
Corn	78	79	39	27	72	59
Onions	69	57	26	38	58	50
Bean	87	88	61	77	83	79

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