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Increasing grape production by reclaiming saline sodic high boron soils in Southern Kazakhstan

Final report

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by

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INTRODUCTION

Grape production is one of the main crop in southern Kazakhstan. A severe yield reduction (about 50%) was observed for many years and the local wine-making industry is under production capacity .It was observed in field and lysimeter studies that one of the main reasons for reducing the vineyard productivity is the high concentration of mobile boron (B) under saline condition.

The reconnaissance of grape plantations were conducted in southern Kazakhstan in 1997. It was found out that 39.5% of stands grow on soils with superfluous content of salts and boron (Table 1).

The obtained data confirmed the statement by Dr. Vinogradov (1957) that the Aral-Caspian lowland and the regions, situated to the east of it and as well as the regions along the break of the earth crust of the Mediterranean geosystem, spreading in Euroasian as a belt in latitude direction almost from Gibraltar to the Pacific. Ocean are rich of boron. The first reason of boron accumulation was the shallow warm sea, occupied the lowland and adjacent premountains in low-tertiary period and deposited thc thickness of saliferous porous rocks. The more salt in the rock the higher boron content in it. The detail investigations of grape plantations of "Karakum" allowed to divide the farm area according to the rate of boron and salts contents (Fig. 1).

The presence of salts in the soil solution influence the growth of plants by osmotic and specific ion toxicity effects and by changing the physical properties of soils. Salinity and sodicity affect soil structure, which" must. be stable for adequate permeability and water infiltration. High sodium levels combined with low soil-water salinity can lower a soil's permeability and decrease its infiltration capacity. The growth of plants is, thus, affected by unavailability of soil water as well as by lack of aeration. The soil fraction which determines the physical behavior of soils most decisively is the colloid clay. Thus, deleterious effect of adsorbed Na, K and Mg on soils permeability is through their effect on clay swelling, dispersion, movement and desorption in the conducting pores.

Boron in soil solution cause injury to plants even when present at low concentrations. Because plants obtain B from the soil solution, and since there is a relatively small range between boron levels in the soil solution that cause deficiency and toxicity symptoms in plants, B distribution between solid and liquid phases of soil under various conditions is important. Boron can be

Table 1: Area of grape plantations with the excess amount of saltsand boron

Regions	Grape areas, thousand of ha		% of saline soils
	Total	saline soil	
Almaty	5.8	0.72	12.5
Kzyl-Ozda	0.6	0.45	75.0
Zhambul	2.8	0.44	15.7
South-Kazakhstan	11 3	6.69	59.2
Total	20.5	8.1	39.5

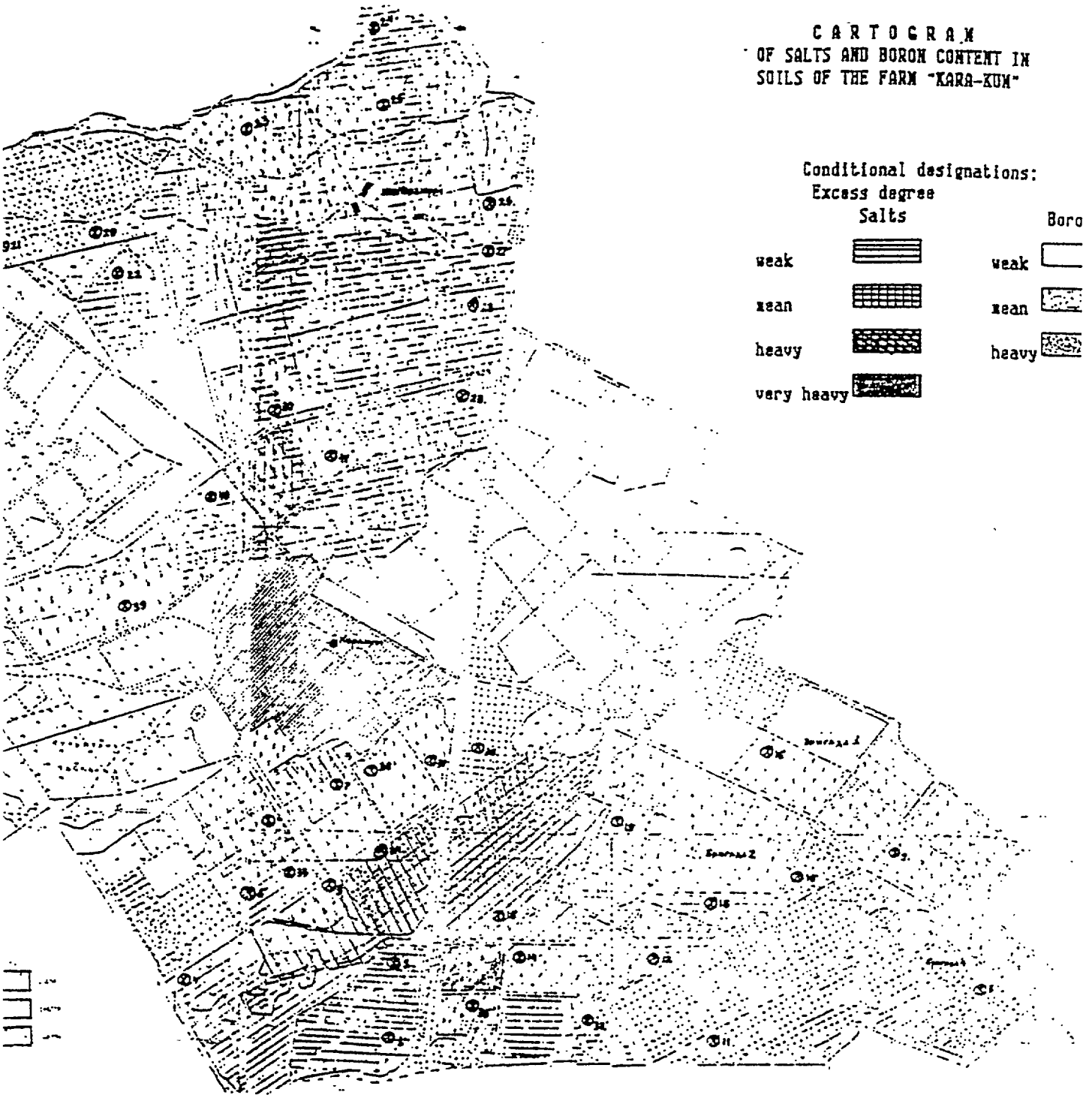

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Fig. 1

specifically adsorbed by different clay minerals, hydroxy oxides of Al, Fe and Mg, and organic matter. Before high-boron soils can be successfully used for agriculture, their soluble boron contents must be reduced to nonphytotoxic levels.

Leaching is the usual way to reclaim soils contain high boron and salt content. Salt leaching involves the dissolution of soluble salts in the soil, the passage of water through soil profiles, and the removal of salt from the root zone. The efficiency of salt leaching defined as the quantity of soluble salts leached per unit volume of water applied. The association of B to the soil adsorption sites must be taken into account when B leaching from soil is concern. However, native B appears to be more difficult to leach than B accumulated from previous irrigation (Hoffman, 1980). The reduced B concentrations that follow the leaching of native high B soils my be temporary . Longer storage times of water in the soil profile results in longer increases in efl1uent B concentrations (Rhoades et al., 1970; Bingham et al., 1972). Boron regeneration is therefore of primary concern during the early stages of soil reclamation, when appreciable residual sources of regenerable B are present. The potential for reestablishing phytotoxic concentrations in a soil is keyed to the relative completeness of the reclamation processes and the rate of B dissolution after reclamation.

The suitability of irrigation water is evaluated-on the basis of B concentration, which determines the potential of the irrigation water to injure plants and reduce yield . It is important, therefore, to clarify the conditions that allow the soil to act as a buffer with respect to B concentration in the soil solution. This knowledge can improve the efficiency of using water and soils of varying B concentrations.

A successful irrigated agriculture requires permanent control of salinity, sodicity , and B levels in soils and improved drainage, chemical treatments and leaching of salts, can reduce natural hazards and make a stable background for intensive cropping.

The ultimate aim of this research project is the improvement of soil management in the southern region of Kazakhstan in order to increase vineyard productivity and to avoid soil salinization and B accumulation in soil solution.

ISRAEL

MATERIALS AND METHODS

Two type of soils (50 kg each) was shipped from Kazakhstan to Israel. The soils represent typical soil from southern Kazakhstan where B and salinity problem are exists. To get uniform soil, the soils were mixed and sieved trough 4-mm sieve. Soils characteristics were obtained by routine procedures: soil texture, CaCO3 content, organic matter, and cation-exchange capacity (Black, 1965). Soluble salts, acidity and electrical conductivity (EC) was determined in water extract from saturated soil paste. Boron was determined colorimetrically using the Azomethine-H method (Keren, 1996).

Permeability of the soils was studied using rainfall simulation. The rainfall simulator is a nozzle type described by Morin et al. (1987). The infiltration was studied using distilled water and rainfall intensity of 43.5 mm/h. The dimensions of a tray were 30 x 50 cm. Four repetitions were run simultaneously.

Boron release from the soils studied by shaking 40 g of soil in 50 mL centrifuge tubes containing 30mL of 0.01 M $CaCl_2$. After appropriate shaking time the suspensions were centrifuged and 15 mL supernatant was removed. Before B determined, active C was added to solution to remove soluble organic molecules. Washing cycle were cried out by replacing 15 mL of the removed aliquot with 15 mL of 0.01 M $CaCl_2$ solution. The soils were resuspended and shaked for appropriate time. This procedure was repeated for each washing cycle.

Soil leaching

Boron dissolution from the two saline high boron soils was studied on aggregate size smaller then 1 mm. Soil samples of 4 g each were transferred to 50 ml centrifuge tubes and leached

with $CaCl_2$ solution at concentration of 0.01 N. After shaking the soil suspensions for 72 hours, the suspensions were centrifuged and the supernatant was analyzed for boron (B). Then, the residual amount of solution that remained in the soil was determined, and 0.01 N $CaCl_2$ solution was added to the tubes at a volume to reach a final solution volume of 30 ml. Then after shaking the soil suspensions for another 72 hours, the suspensions were centrifuged again and the supernatant was analyzed for boron (B).

During the third cycle of shaking, the pH of the suspension was increased to 10 using $Ca(OH)_2$ saturated solution. The shaking time for this cycle was 12 hours. Thereafter, the suspensions were centrifuged again and B concentration in solution was determined. Then, the pH was reduced to 7 by HCl and the solution volume was brought to 30 ml. After overnight shaking, the suspensions were centrifuged again and the supernatant was analyzed for boron (B). At this stage the B concentration in solution was below the detection limit.

Adsorption Isotherms

Boron solutions at concentration of 1000 ppm at pH 6, 7.5 and 9 were prepared using $Ca(OH)_2$ and HCl solutions. The final $CaCl_2$ concentration in these stock solutions was 0.01N. The stock solutions were diluted in order to obtain final B concentration solutions of 10, 25, 100, 250 and 400 ppm, keeping the $CaCl_2$ concentration constant at 0.01 N and the pHs were adjusted to the values mentioned above.

After pH adjustment, the soil suspensions in the tubes were centrifuged and the solution replaced with boron solutions having the appropriate $CaCl_2$ concentration and pH. The suspensions were then brought to 30 ml by adding an appropriate volume $CaCl_2$ with the desired pH, taking into account the volume of solution remaining in the soils after centrifugation.

Preliminary experiments indicated that adsorption equilibrium was established less than two hours after boron was added to the suspension. However, the samples were shaken 24 hours. The suspensions were then centrifuged, and the supernatant was analyzed for boron. The amount of adsorbed boron was determined by the difference between the amount added and that found in solution at equilibrium.

Boron dissolution and transport in soils under leaching

The soils were sieved and soil aggregates smaller than 2 mm were used in this experiment. 236 g of sieved soils were packed in plastic columns with the dimensions of 5 cm in diameter and 8 cm long. The bulk density of the soils in the column was 1.3 g cm^{-3}.

The soils were saturated with 0.01 N $CaCl_2$ solution and then leached with the same solution at the rate of 10 mm h^{-1}. The leachate was collected in tubes by fraction collector and analyzed for boron.

Field study

Toxicity symptoms of boron were observed in grape leaves in various regions in Israel. The objective of the present study is to assess the grape response to boron concentration in soil solution.

Eight plots were selected in the Jordan Valley and the boron concentration in saturation paste solution at various soil depth was analyzed.

RESULTS

Soil description and characteristics

Table 2 and 3 summarize some of the soils characteristics. The soil types, based on U.S. soil classification, are being defined as loam for soil 1 and silt clay loam for soil 2. The two soils are calcareous soils which contain around 15% $CaCO_3$ as being reflected by the batch pH of the water extracted saturated paste. The organic matter contents are low as expected from arid soils. The higher organic matter content in soil 2 (1.85%) can be related partly to plant residues. The cation exchange capacity of soil 1 is much lower then soil 2 probably because of higher clay content in soil 2. The salinity of soil 1 is relatively low with high exchangeable sodium percentage (ESP) value. Soil 2 contains more soluble salts with low ESP value. The higher salinity in soil 2 is a result of higher solubility of the cations: Ca^{2+} , Mg^{2+}, K^+ and Na^+, and mostly the anion SO_4^{2-}. The high concentrations of soluble Ca^{2+} and SO_4^{2-} indicates the presence of gypsum in soil. Boron concentration in the water extracted saturated paste is 0.42 ppm for soil 1 and almost twice of that in soil 2.

The saline soil (soil number 2) contain boron at greater level than the less saline soil (soil number 1). The boron concentration in the saturated paste is 0.42 and 0.80 ppm for soils 1 and 2, respectively.

Soil permeability

The infiltration curve for soils 1 and 2 are presented in Fig. 2. The initial infiltration rate values were 17.55 and 25.2 mm/h for soils 1 and 2 respectively. The lower infiltration rate of soil 1 is a result of the higher ESP value (Table 2). The final infiltration rate value (around 4.5 mm/h) was the same for the two soils.

Table 2

Soil No.	Hygroscopic Water	Clay	Silt	Sand	$CaCo_3$	OM	CEC	ESP
	(%)	------- (%) --------			(%)	(%)	meq/100 g	(%)
1	1.55±0.05	23.8	29.4	46.8	15.5±0.2	0.62 ±0.02	7.2 ±0.3	8.3±0.2
2	2.50±0.05	35.0	48.7	16.3	14.0±0.2	1.85 ±0.03	14.5 ±0.2	4.0±0.4

Table 3
Saturated paste

Soil No.	pH	EC	water content	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	SO_4^{2-}	B	P
		(dS /m)	(%)	———	———	(mmol /L)	———	———	———	—(ppm)—	
1	**8.00**	**0.63**	**39.6**	**0.55**	**1.03**	**1.82**	**0.40**	**0.68**	**1.01**	**0.42**	**0.49**
	0.05	0.02	0.1	0.02	0.06	0.05	0.06	0.08	0.05	0.04	0.08
2	**8.21**	**1.47**	**57.5**	**1.05**	**1.75**	**4.25**	**2.56**	**1.23**	**5.06**	**0.80**	**0.82**
	0.03	0.02	0.3	0.05	0.106	0.10	0.05	0.04	0.25	0.07	0.09

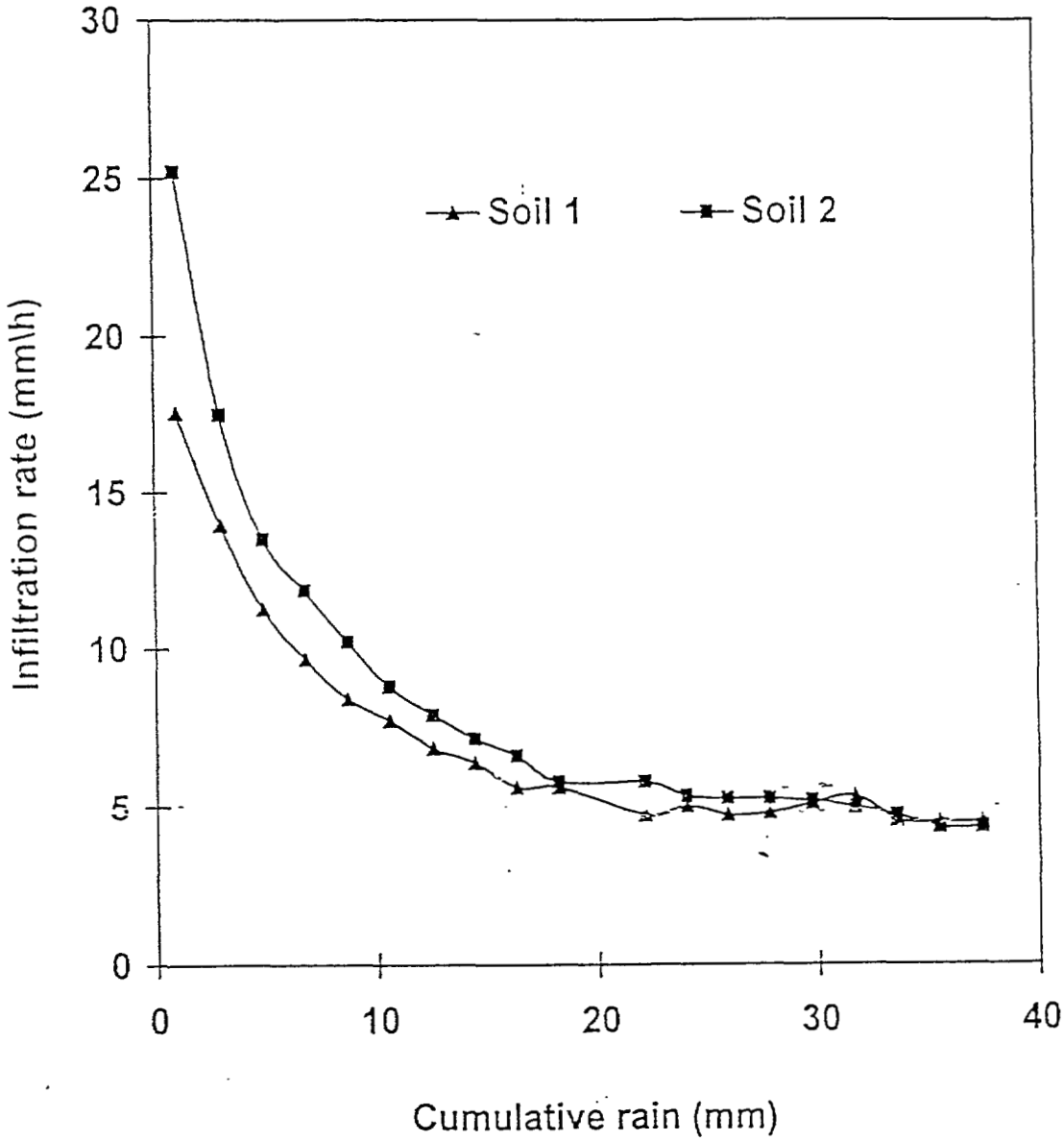

30
25
20
15
10
5
0
Infiltration rate (mm\h)
Soil 1
Soil 2
0
10
20
30
40
Cumulative rain (mm)

Fig.2

Release of natural B from soils

Kinetic curves of natural B released from soils 1 and 2 are presented in Fig. 3. Kinetic experiments performed as long as 240 h indicate that B concentration in solution increases with time. Boron concentration in soil 1 solution after 1 h of equilibration time, with 0.01 M $CaCl_2$, was 0.35 ppm. After 240 h, the concentration reached the value of 0.75 ppm. More B was released from soil 2 compared to soil 1. After 240 h, the amount of released B from soil 2 (49.4 mg/ kg soil) was 2.2 times higher then soil 1. The fact that equilibrium was not reached after 240 h suggested that B was probably released from B containing minerals. Usually desorption time of B from soil adsorption sites is shorter.

In order to evaluate the capability of the soil to adsorbed boron , a leaching procedure was carried out. Boron released from the soils was determined in leaching cycles. The amount of B released and cumulative B released as a function of washing cycles after 1 h of equilibration time are presented in Figs. 4a and 4b, respectively. The amount of B released from soil 2 decreases significantly with leaching cycles and at the third cycle the B released almost reached the amount released from soil 1. Thus, it seems that the initial B is released from soluble compounds and therefore is removed easily. In order to check this assumption, pre-leaching cycle was performed (Fig. 5). The pre-leaching times were 1 and 24 h (Figs. 5a and 5b, respectively). Boron released from washed soils increased with an increase in the equilibration time. In all cases B released from soil 2 was significantly higher then soil 1. For most of the cases, the amount of B released after pre-leaching time of 1 h (Fig. 5a) was higher then that released after 24 h (Fig. 5b). However, the accumulated amount of B after pre-leaching time of 24 h was higher than after 1 h. These results indicate that the released B from the soil is highly depended on the number of leaching cycles.

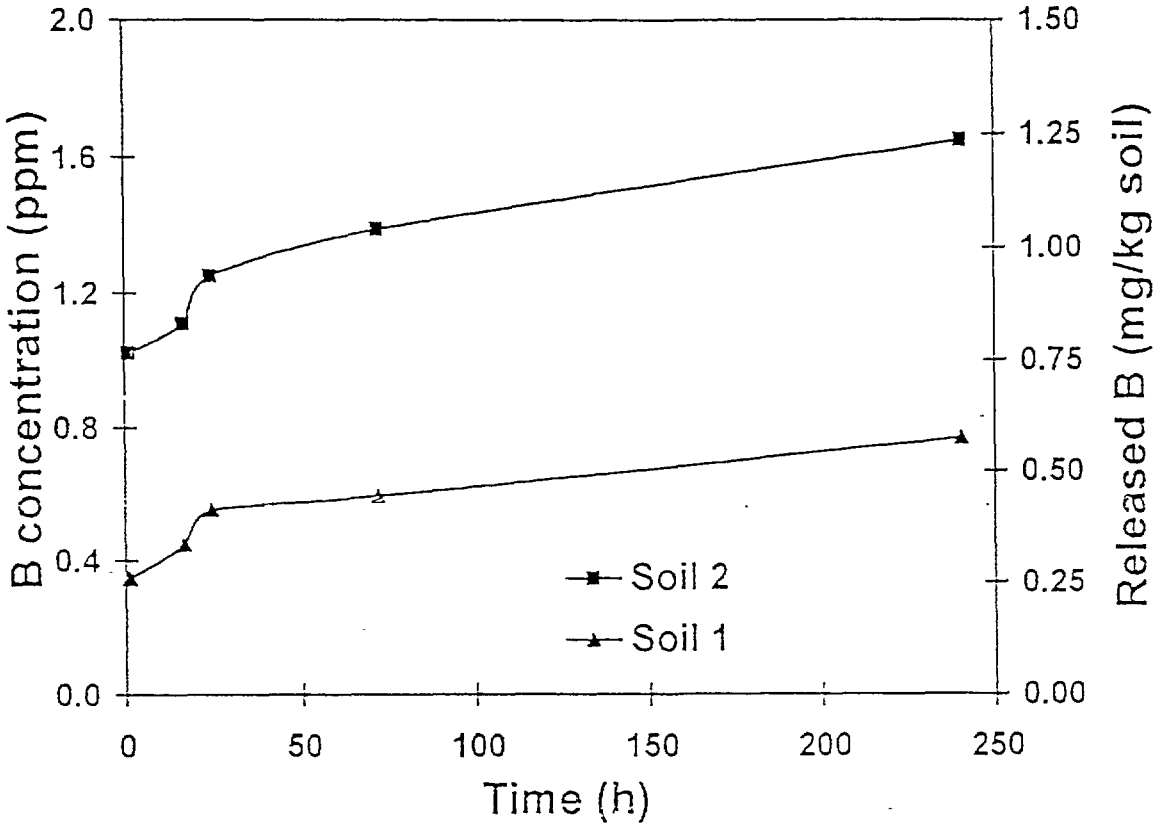

2.0
1.6
1.2
0.8
0.4
0.0
B concentration (ppm)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Released B (mg/kg soil)
0
50
100
150
200
250
Time (h)
Soil 2
Soil 1

Fig.3

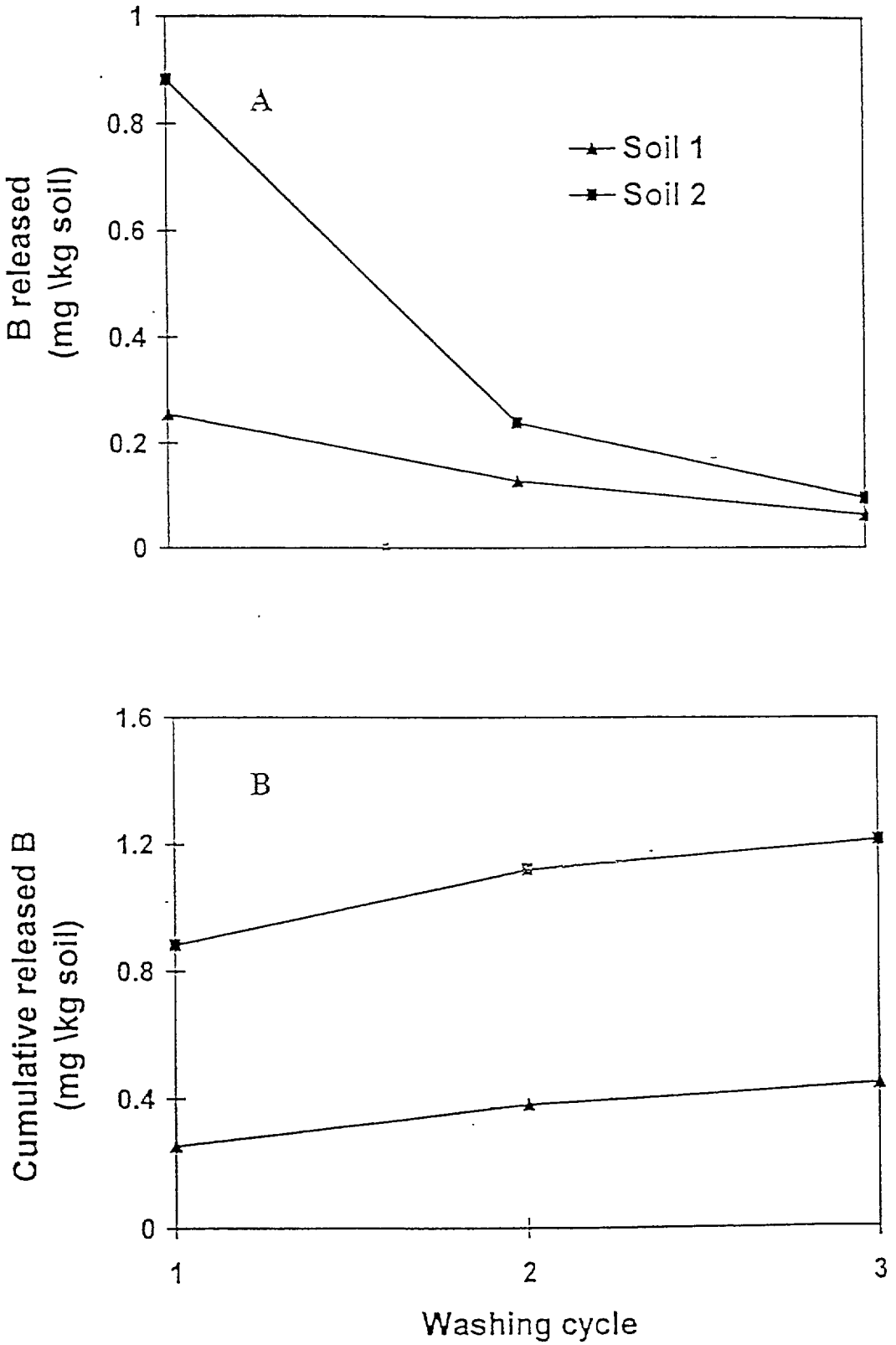

A
Soil 1
Soil 2
B released
(mg \kg soil)
1
0.8
0.6
0.4
0.2
0
B
Cumulative released B
(mg \kg soil)
1.6
1.2
0.8
0.4
0
1
2
3
Washing cycle

Fig.4

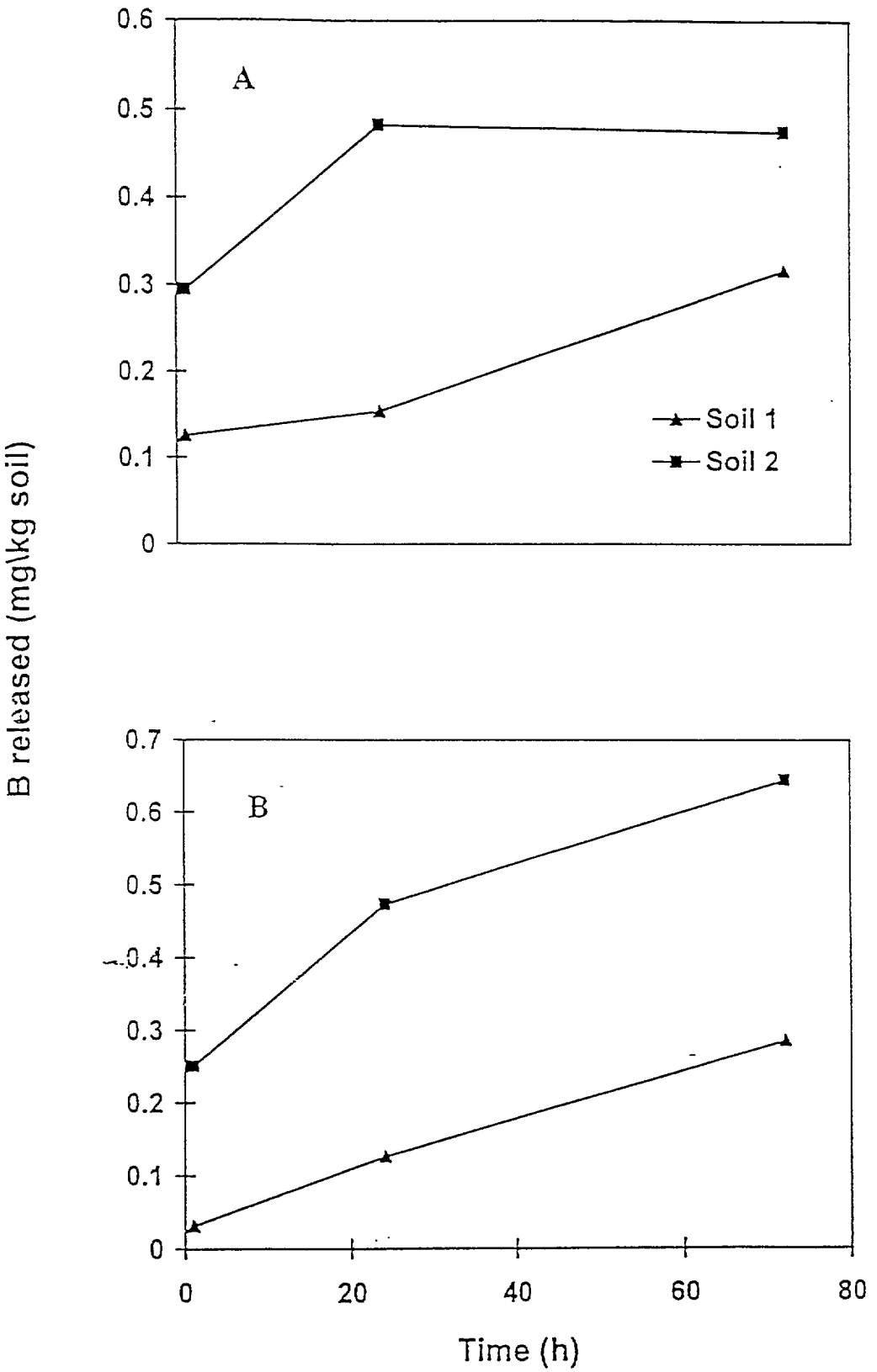

A
B
Soil 1
Soil 2
B released (mg\kg soil)
Time (h)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
20
40
60
80

Fig.5

Boron dissolution and transport in soils under leaching

The boron concentration in the leachate decreases as the leachate volume increases (Fig. 6). The boron concentration reached a steady state value after leaching of about 16 pore volumesfor both soils. The boron concentration in the leachate was significantly higher for the saline soil (soil 2) than for the less saline soil. These results indicate that the amount of leachable boron for the less saline soil is about 175 mg per kg soil whereas the value for the saline soil is greater than 420 mg per kg soil. Since the boron concentration in the saturation paste of soils 1 and 2 is 0.42 and 0.80 mg per liter, respectively (Table 3), the boron amount in the saturation paste related to the soil is 0.17 and 0.46 mg per kg of dry soil for the two soils, respectively. Therefore, the leaching requirement for boron for the saline soil is much greater than that for the less saline soil which is about 1000 pore volumes. These results indicate that the main source of boron in the saline high boron soils is primary and /or secondary boron minerals existing in these soils.

Adsorption Isotherms

Results in Fig. 7 show that in accordance with Keren and Bingham (1985) boron adsorption on the soils is a function of both equilibrium boron concentration and solution pH. Boron adsorption increases with the pH in the pH range of 7.0-8.9, and the saline soil (Soil 2) show greater affinity to boron than the less saline soil (soil 1).

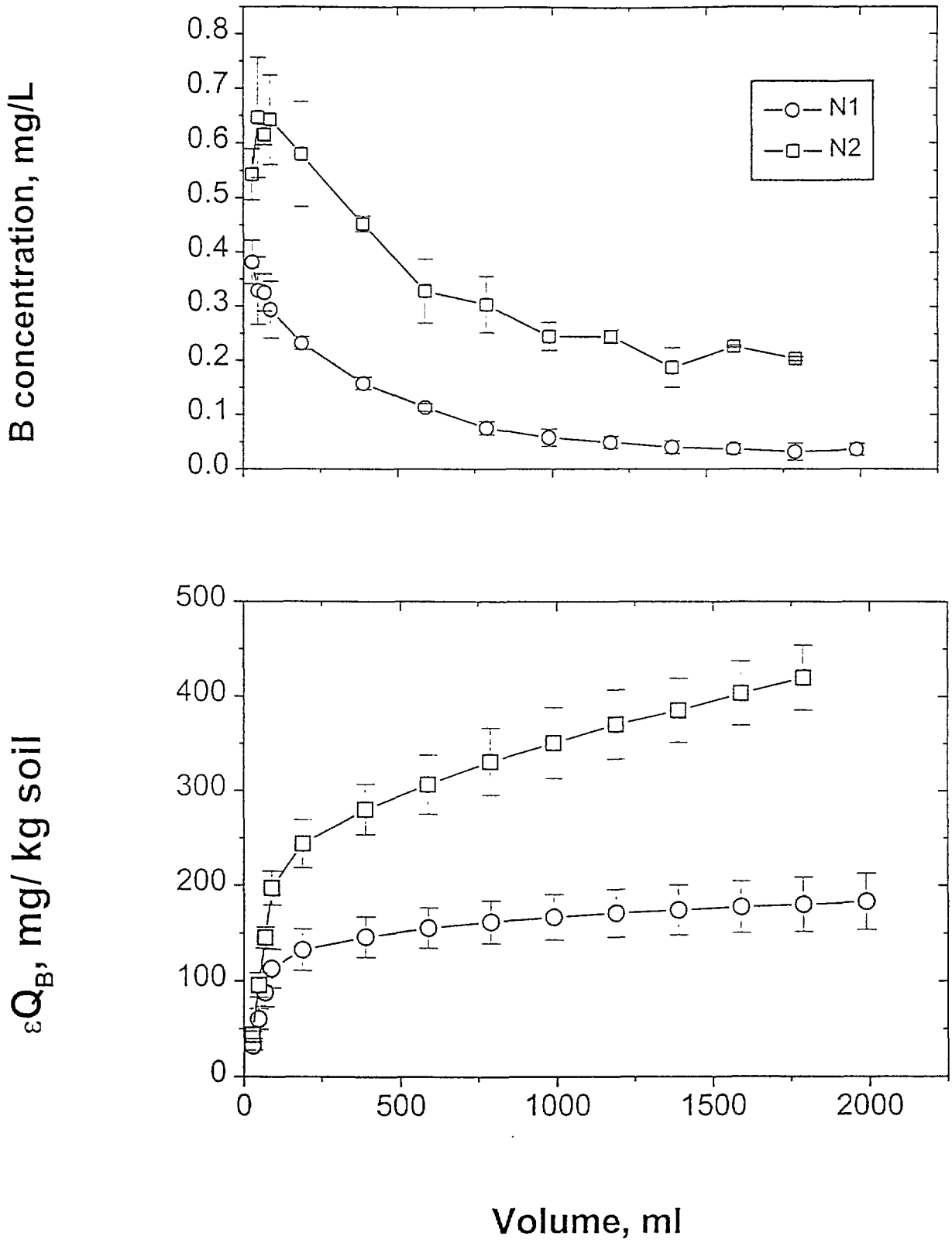

B concentration, mg/L
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
N1
N2
εQB, mg/ kg soil
500
400
300
200
100
0
0
500
1000
1500
2000
Volume, ml

Fig.6

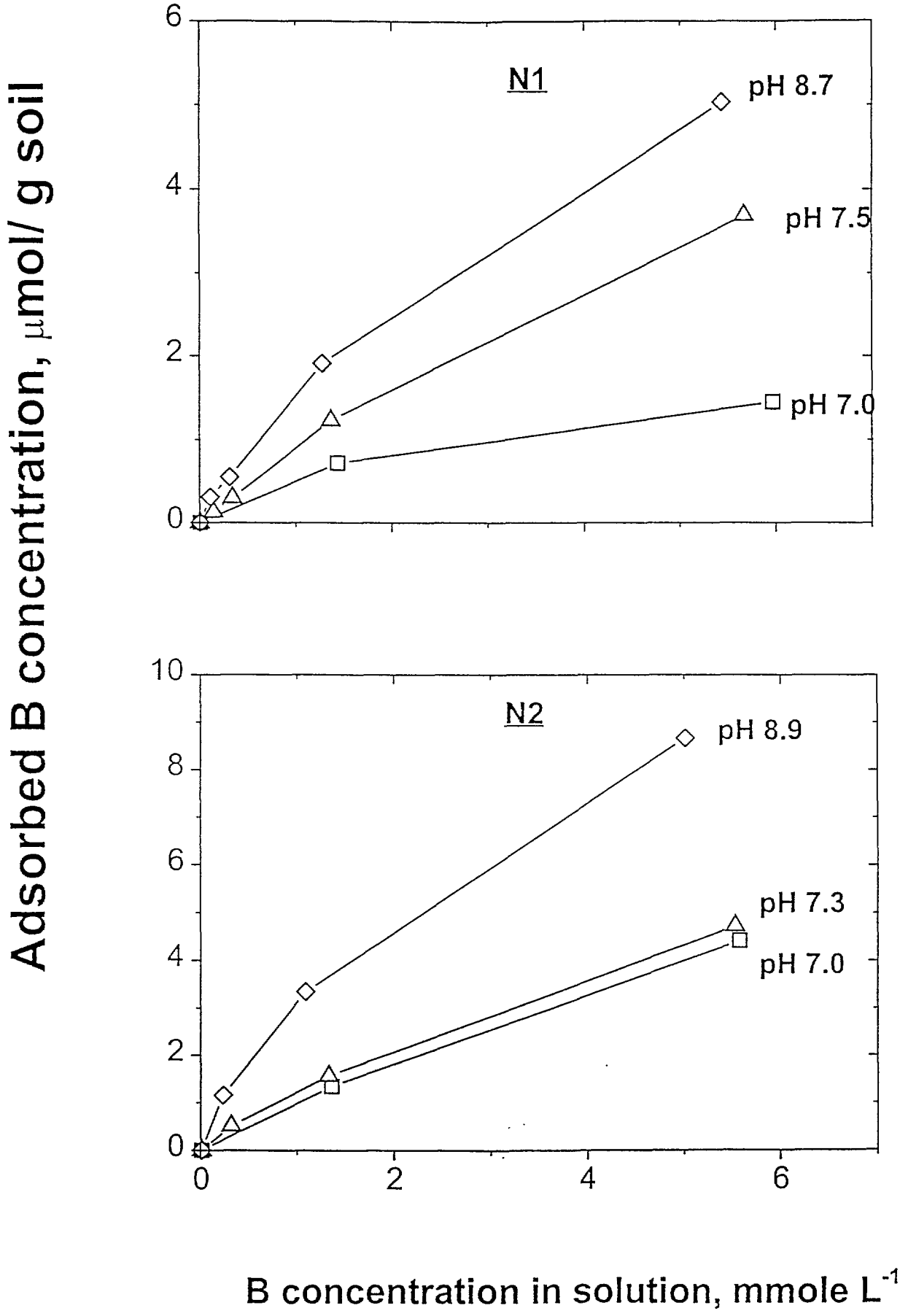

Adsorbed B concentration, μmol/ g soil
N1
pH 8.7
pH 7.5
pH 7.0
N2
pH 8.9
pH 7.3
pH 7.0
0
2
4
6
8
10
B concentration in solution, mmole L-1

Fig.7

Field study

The results of 4 representative plots are given in Figurs 8 and 9. The results indicate that boron level is higher in the uncultivated soils than in the cultivated soils but there is a correlation between the boron level in the uncultivated soil and the cultivated soil at the same location. Boron concentration in leaves at the end of the growing season was significantly greater than that at the beginning of the season in all plots (Fig. 10). The boron concentration was in the range of 300 to 1030 ppm. These values are way above the toxicity threshold value. The boron concentration in the leaves was in correlation with the boron concentration in the soil (Figs. 8 and 9).

The concentration of nitrogen, phosphorus and potassium in the leaves were determined in the beginning and the end of the growing season (Fig. 11-13). The concentration of these elements in the leaves were lower in the end of the season than in the beginning. Based on these results it was recommended to change the irrigation regime in such a way that most of the active roots will concentrate in the upper layers of the soils.

Fig, 8 . Boron concentration in saturation past in deferent depth at the beginning of the season. The grapes were grown uncovered.

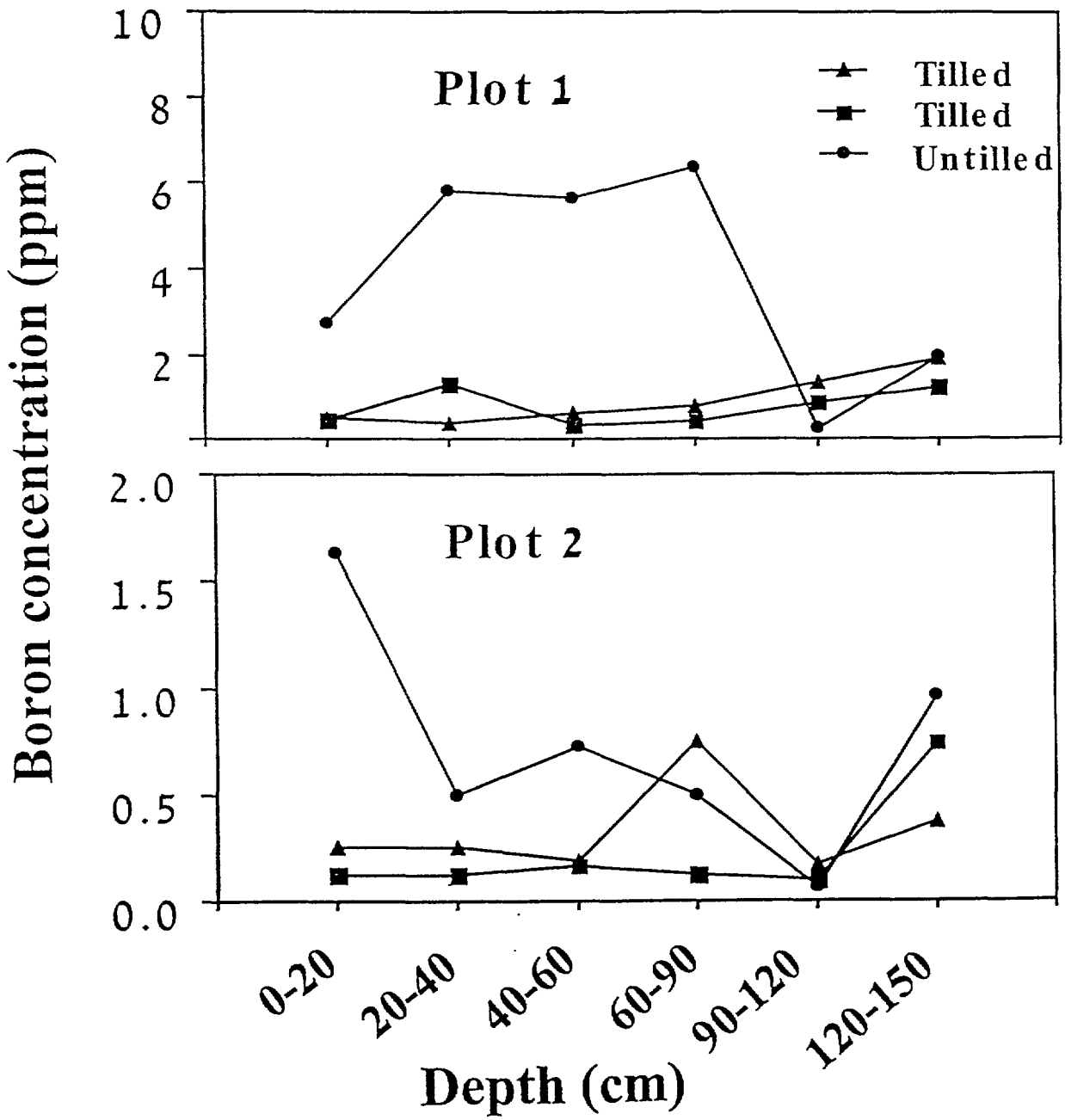
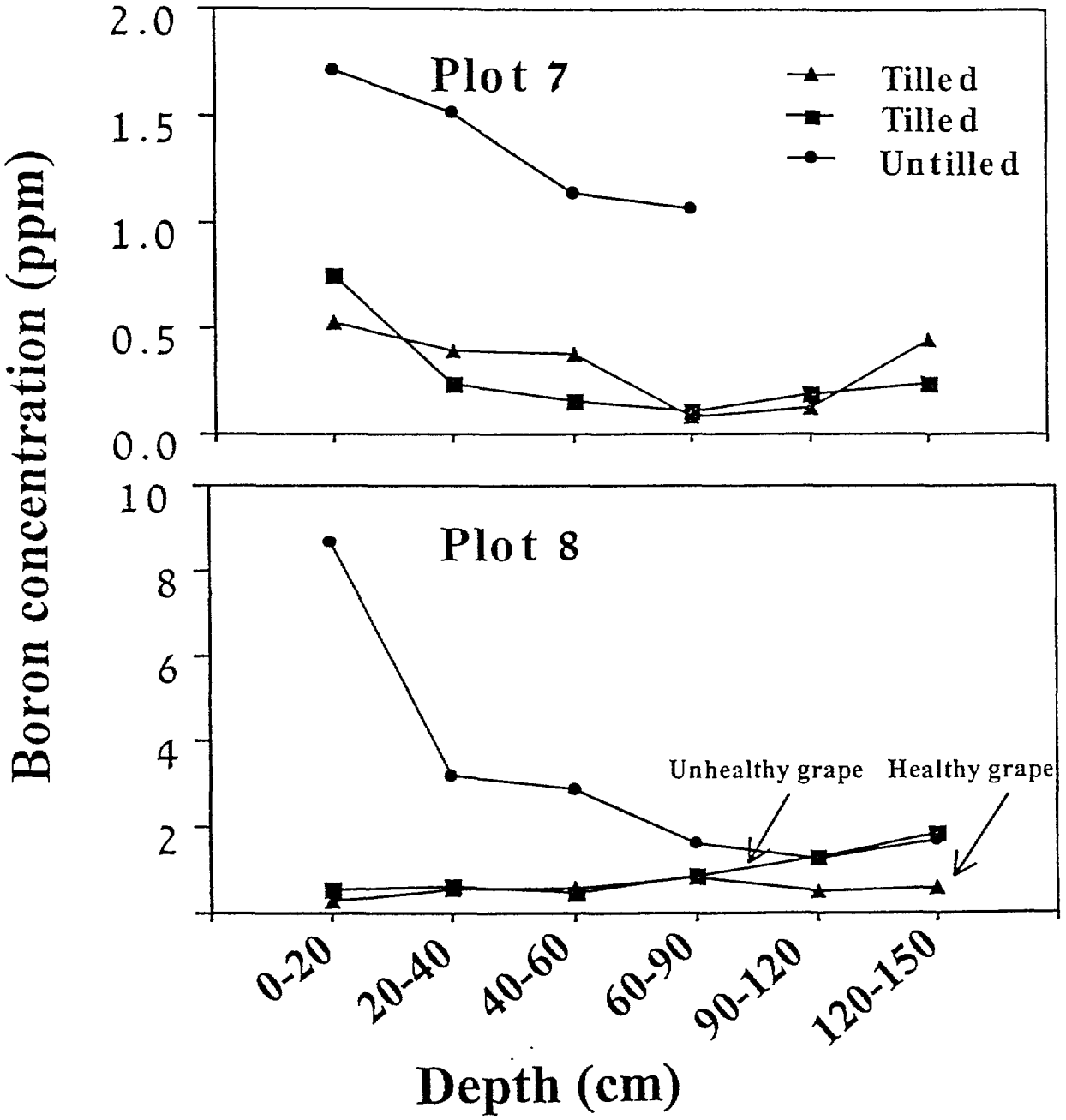
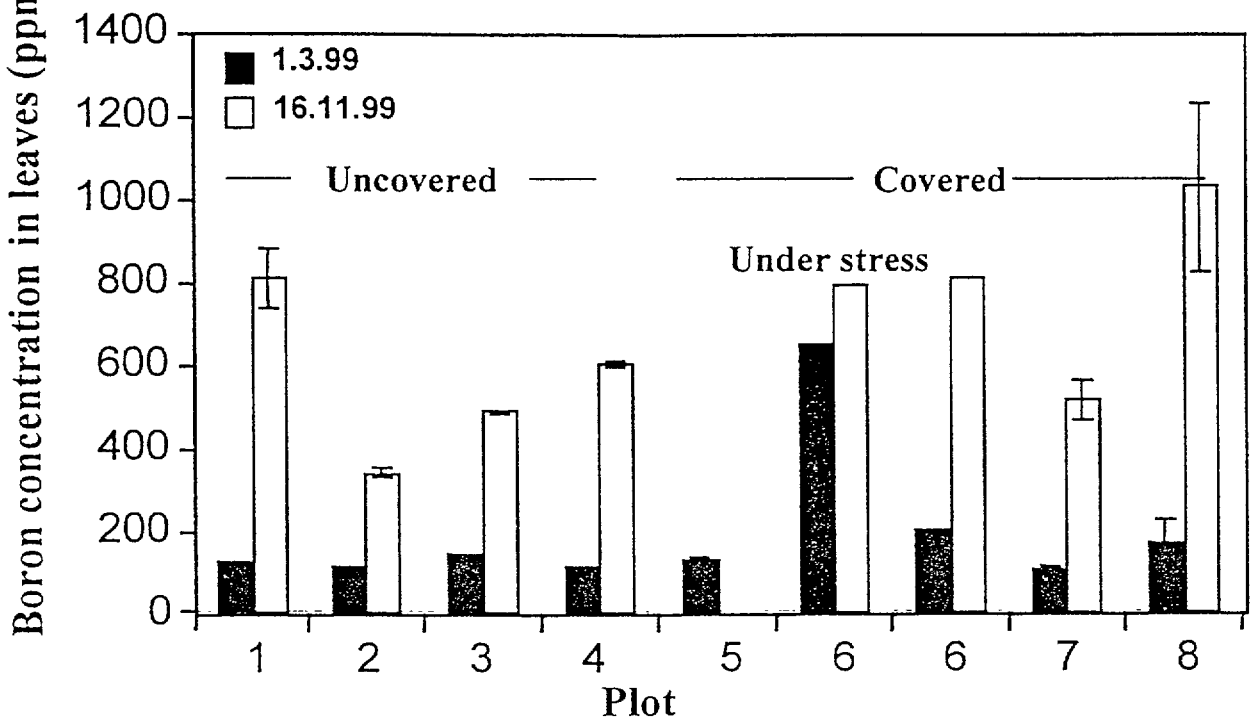


Fig. 9. Boron concentration in saturation past in deferent depth at the beginning of the season. The grapes were grown covered.



Fig, 10 Boron concentration in leaves in deferent plots at the beginning and at the end of growth season.



Fig, 11 . Nitrogen concentration in leaves in deferent plots at the beginning and at the end of growth season.

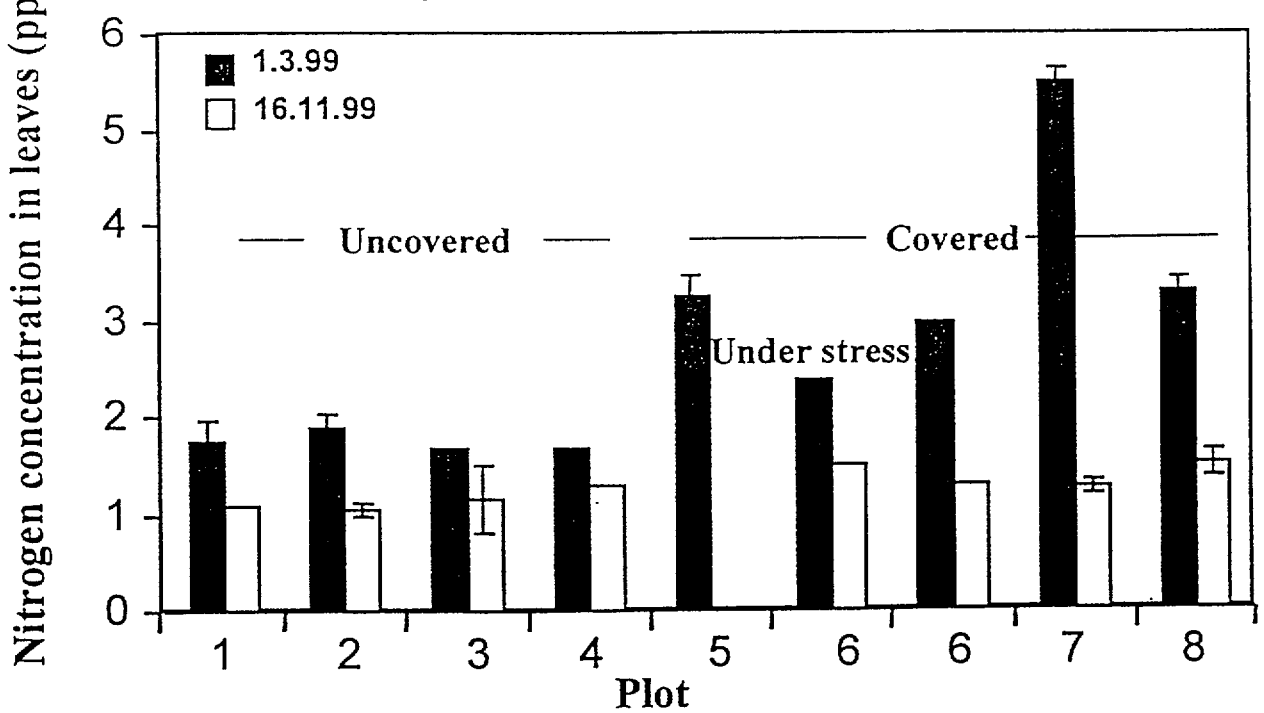


Fig. 12 Phosphorus concentration in leaves in deferent plots at the beginning and at the end of growth season.

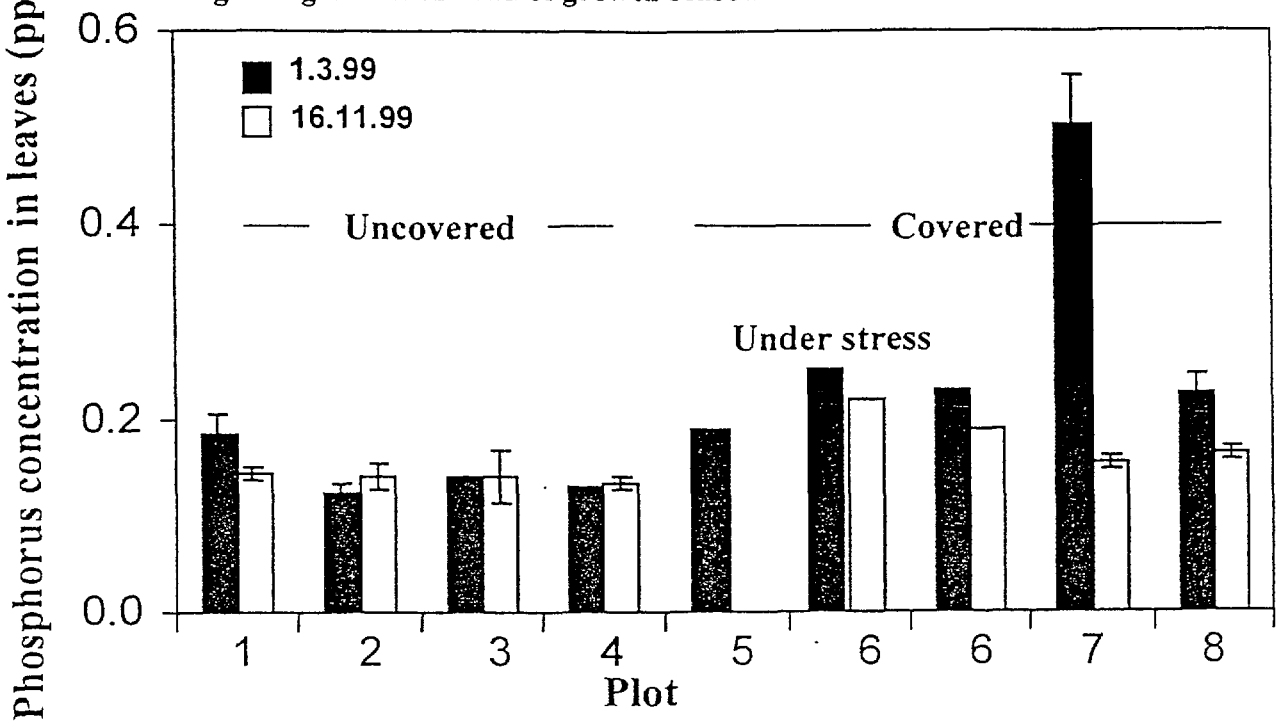
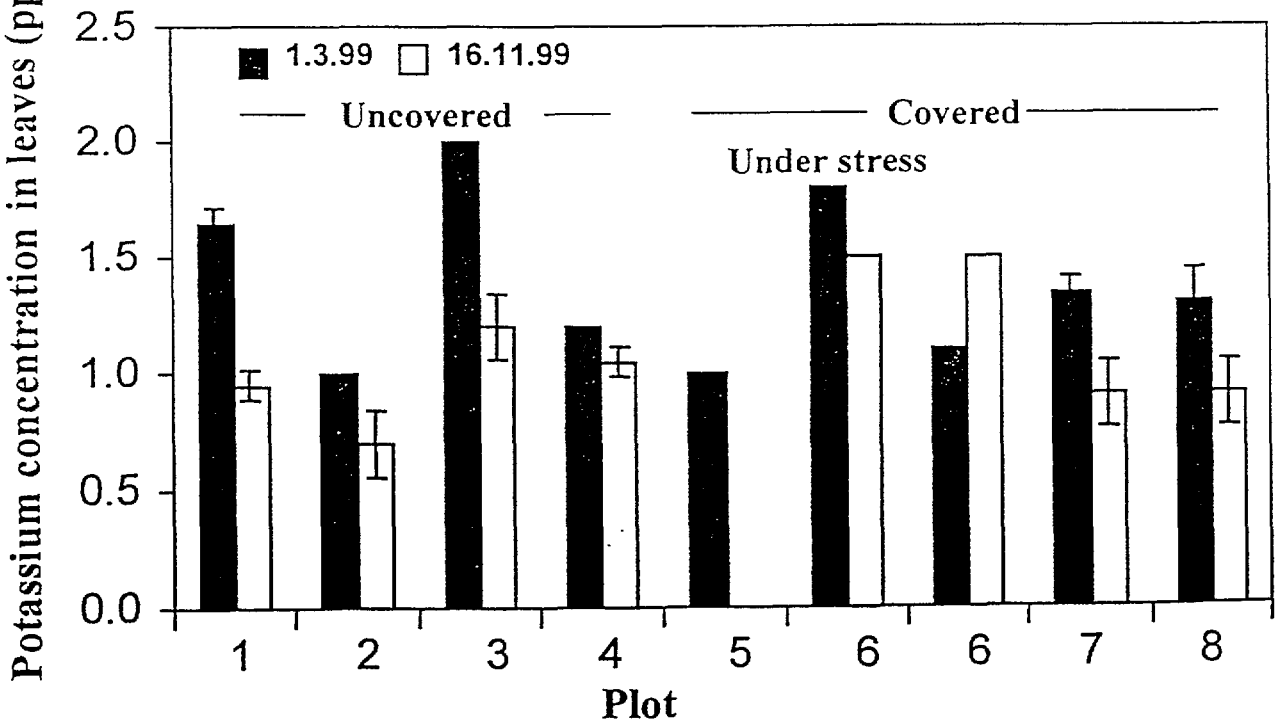


Fig. 13 Potassium concentration in leaves in deferent plots at the beginning and at the end of growth season.



KAZAKHSTAN

The field experiments were laid out on the plots of 7 and 27 soil profiles according to the investigation program. The climate of the region is (severe) continental. The beginning of winter is at the end of November, and the end of winter is at the second part of February. Annual air temperature is -20 ^{0}C, and half of the years it is lower that -25 ^{0}C, once in 10 years the temperatures droped to -31 ^{0}C, (at very severe winters even to -42 ^{0}C. Grape production may be developed only under conditions of soil covering.

Spring frosts are ceased in the second part of April, in inferable years in the first ten-day period of May. The probability of grape damage by spring frosts after bud breaking is inconsiderable -once in 20 years. Autumn frosts, falling leaves, non-ripen vines, berries, repeated at the second ten-day period of September only once in 30 years. Summer is hot and very dry, air temperature is 40-42 ^{0}C. The length of the vegetative period is 200 days. The sum of positive temperatures is 4400, what provides the late ripening of grapes. The days of relative air humidity lower than 30% are observed during 4 or sometimes 6 months.

The major part of precipitation falls between October and May. The snow cover the ground at a layer of about 4-5 cm and it is not constant. The soils are sierozemic soils on ancient terraces. Bedrocks are loess-like and loosed loams,underlying in different levels of salinity, thin-porous sediments, having ockre spots – carbonate deposits.

The factors determining plant productivity are the following: light, heat, water and nutrient elements. Light and heat are cosmic factors, which cannot be directly regulated. The coefficient of their use may be increased by structure optimization, rational distribution of plants and breeding of more productive varieties. Optimization means of nutrition regimes are the following: 1 — removing of the excess of harmful substances from root soil layers and 2 — reducing their toxicological influence on soil and plant. The efficiency of the above mentioned methods is determined by concrete growth conditions.

The improvement of mineral nutrition may be obtained by optimization of element ratio. For soils with low levels of salts and boron, the calculation of necessary fertilizer doses is conducted by the equation of optimal balance in ratio with actual element balance in soil

$$ED = \frac{K\,20 : N\ (opt.)}{K20 : N\ (fact.)}$$

Where ED is element dose.

It actual correlation doses not exceed optimal meaning the fertilizer doses are calculated for previous element, if actual correlation exceeds the optimal balance the calculation is conducted for subsequent element.

For soils with high levels of salinity and boron, the positive results cannot be reached by the optimization of element correlation, as the concentration of soil solution will enhance to soil toxicity. In this case the optimization of nutrition regimes may be reached both at the expense of removing excess boron and salts from root-zone and application of missing minimum elements and at the expense of element-antagonist use, reducing negative boron and salt influence on a plant.

Water demand by grapes was based on the vegetation periods. At the beginning of shoot growth phase water requirement is low (Fig. 14). From the second half of shoot growth phase water-consumption is sharply increased. The highest water demands is at the beginning of August. In this period the most vigorous increment of grape bush biomes is observed. In the second half of phenophase of berry ripening water consumption reduces to minimum in the defoliation stage. For full plant water consumption it is necessary to differentiate the irrigation

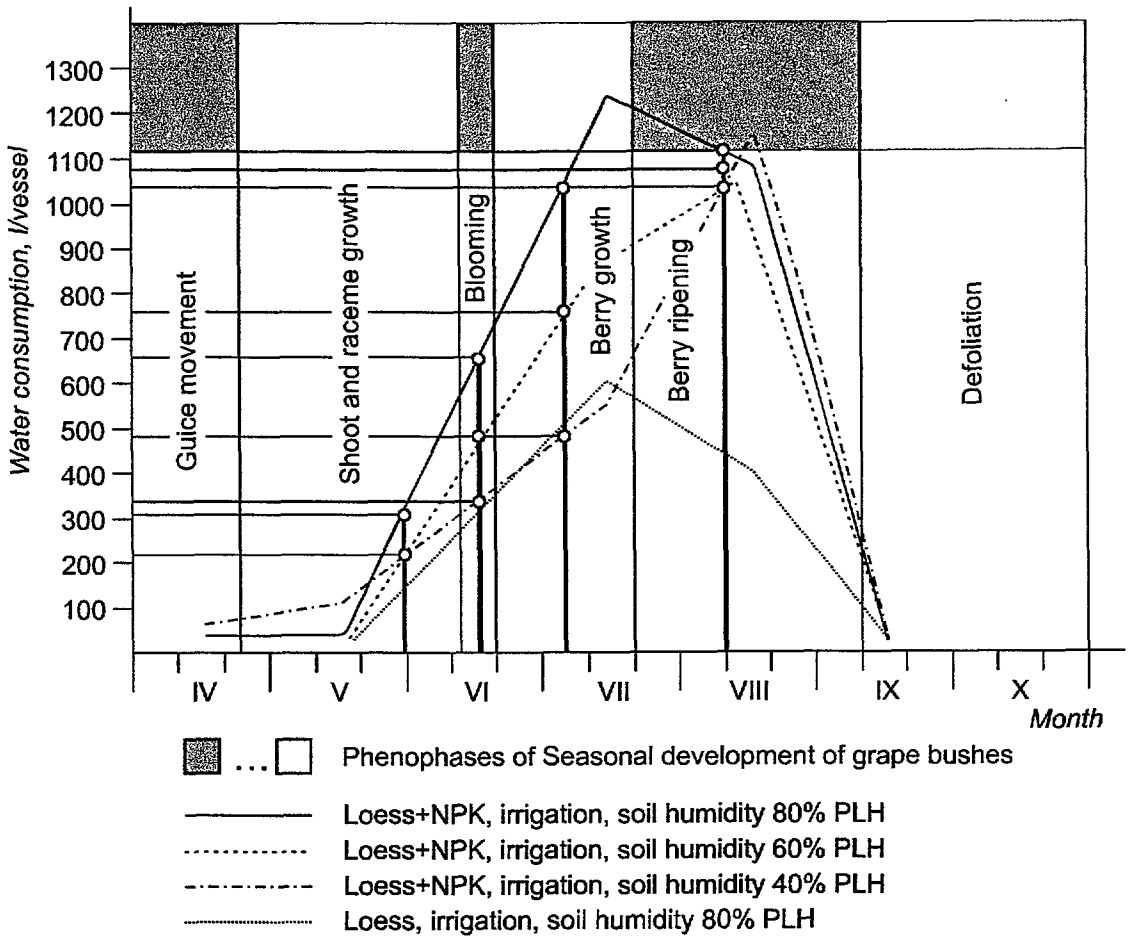


Fig.14 Change of water comsuption in months.

according to the plant development periods. Shoot growth and number and leaf area decreases as the amount of irrigation water decrease. The correlation coefficient for shoot length and number of shoots is 0.60 and 0,58, respectively. The correlation coefficient for leaf area changes, depending on the yield. It was observed that a correlation exists between grape yield and water consumption (Furs, 1977; Turyaanskiy, 1967; Turmamidze 1981). The dependence of yield on water consumption is shown on Fig. 15. The slop of the line drawn from the beginning of coordinates to point «a» is maximum, corresponding to the lowest water use. At this point the yield is the highest and the applied water per unit of yield is the lowest. Lysimeter investigations showed that in the phases of juice movement and the beginning of shoot growth soil moisture is not lower than 80% PLH. In this period of time, irrigation is not needed. In the second half of shoot growth phase, plant growth and inflorescence was observed, the twenty-hour increment of young shoots is about 6—8 cm. For this period of time, shoots reached 60% of their final length and grape inflorescence and flower organs are fully formed. The highest water consumption of grape plants in this period is observed under irrigation with preirrigation limit moisture of 80% PLH (Fig. 16).

Water consumption of grapes increase in the phase of blooming. Soil moisture in this phase of grape development should be not lower than 80% PLH. Optimal soil moisture is reached under preirrigation limit humidity of 60 PLH. At the end of ripening berry phase, water consumption is sharply decreased. At defoliation phase, soil moisture does not essentially influence plant water consumption. Thus, irrigation should be conducted when the soil moisture reached the level of 40% PLH. The maintenance of optimal soil moisture during the vegetative period increases grape productivity and reduces toxicological effects of boron. For elaboration of means for land reclamation when boron is in excess and readily soluble salts according to the results of field and laboratory experiments, vegetative and lysimeter experiments were laid out.

Experiment scheme:

NPK according to calculation

Biohumus of 600 kg/ha (B)

B+ Zn_{40} mg/kg soil

B+ Zn_{60} Al_{260} Mg_{66}

B+ Zn_{40} Al_{230} Mg_{280}

NPK + Zn_{60} Al_{260} Mg_{60}

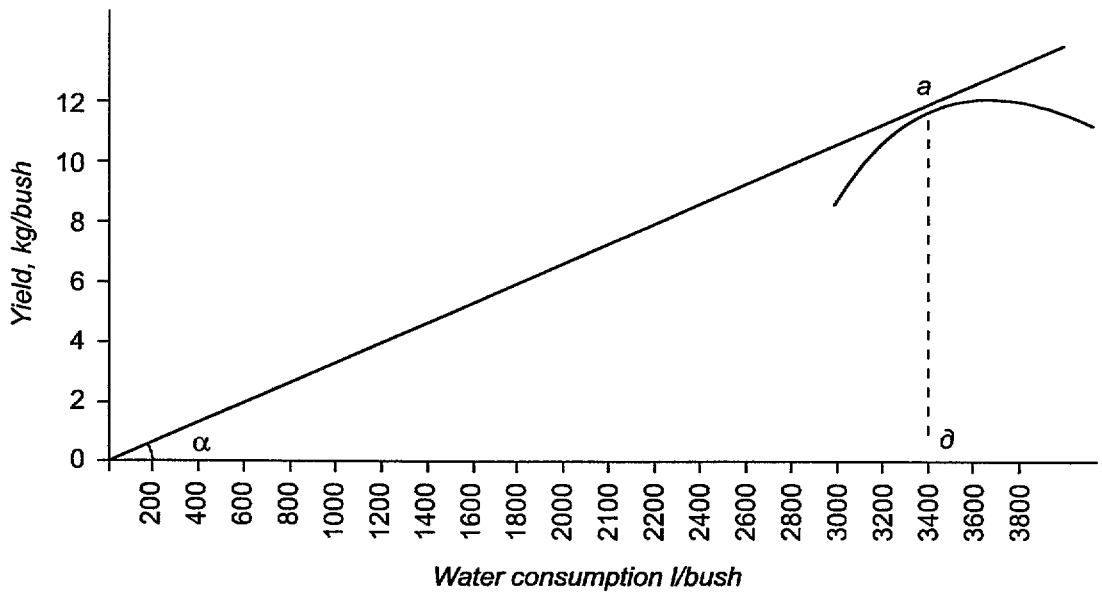


Fig. 15. Yield dependence on grape water consumption.

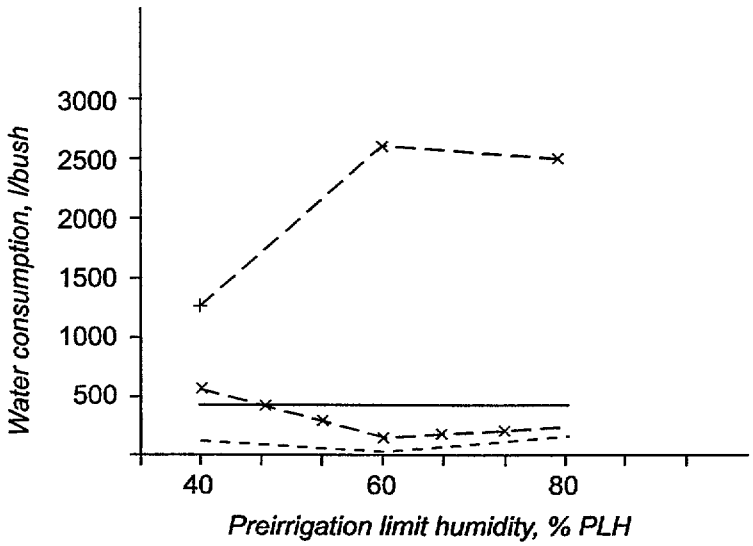


Fig. 16. Preirrigation limit humidity, % PLH.

Fig. Connection of grape water comsumption with soil water reserve according to interphase periods. 1 — shoot growth, blooming; 2 — beginning of berry growth; 3 — end of berry growth, beginning of ripening; 4 — end of ripening, defoliation.

Lysimeter experiment was carried out in containers with the capacity of $3m^3$. The above mentioned variables were studied on two soil specimens distributed under vineyards in the south of Kazakhstan. The experiment was carried out with four replicated. The experiments were laid out on a scheme of divided plots.

The objectives of the experiments:

Growth peculiarities and plant productivity.

Absorption photoactive radiation (Ph. A.) energy by plants and its use in photosynthesis processes yield formation. The photosynthesis activity depends on the methods of soil reclamation.

The indexes of water exchange leaf watering, water-holding capacity, concentration of cell juice, transpiration.

Permeability of cell membranes by the method of electroconductivity measurements.

Biological soil activity according to Mishustin.

The revealing of elements-antagonists by application method according to Nelidov.

Based on the results obtained from the vegetative and the lysimeter experiments, field experiments were carried out on the lands of AO «Karakum».

The analysis of the soil in the experimental sites showed low content of Zn, excess of boron and readily soluble salts (Tables 4 and 5).

Table 4.

The characteristic of initial soil state

Soils	Humus, %	CO_2, %	pH	N hydrolyzing.	Available elements, mg/100g		Firm residues, g/l
					2 5	2	
Strongly salted soils with higher boron content	1.80	7.22	8.2	0.98	0.8	30	2.84
2. Weakly salted soils with high boron content	2.35	6.15	8.0	3.89	4.6	98	0.152

Table 5.

Initial content of microelements, mg/kg

Soils	Zn	Cd	Co	Cu	B
1. Strongly salted soils with higher boron content	61.22	0.63	1.99	13.12	1.86
2. Weakly salted soils with high boron content	not/disc	0.66	1.85	15.33	5.00

Uniformity of plantings was determined by the size of shoot increment. Calculations showed that the uniformity is in the limits of experiment precision and it is not able to influence investigation results.

In vegetative experiment under greenhouse conditions the beginning of bud opening in grape plantings, of the Perlet variety, was caried out in pots in the third of November, was observed in 3.12.97, and the end of vegetation in 4.06.98. the duration of vegetation was 6 months. After pruning of ripe shoots by bud opening was observed in 2 days. Practically the biological dormancy of grape plantings grown in greenhouse, was not observed. The end of the second planting vegetation was in November 1998. During the first calendar year of investigations experimental plants passed 2 vegetation.

Controlled pots conducted irrigation of plantings by weighing. The moisture was maintained on the level of 80 in the first half of vegetation, in the second half — 60 and 40% PLH. Water

consumption of grapes increased with time and was linearly dependent with temperature. This observation pointed to prevailing role of unproductive physical evaporation in discharge part of water balance of young grape plants and relatively low amount of water, discharged for transpiration (Fig. 17). Antagonism processes and optimization of mineral nutrition is indissoluble. On weakly polluted soils they act as a single whole with the

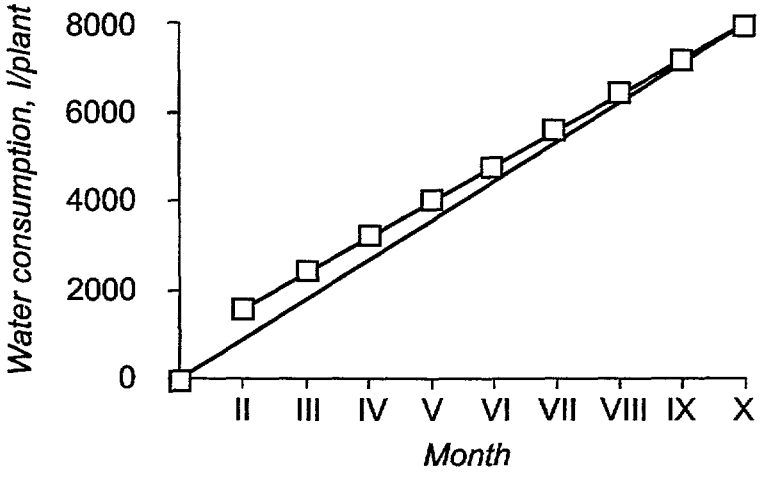


Fig. 17. Water consumption of grape.

Predominance of regime optimization factor of plant mineral nutrition. On strongly polluted soils, the processes of element antagonism are predominant. According to existing situation, means of polluted soil reclamation should be differentiated, taking into account their efficiency in connection with formed environments.

The growth of plant biomass is determined by character and intensity of physiological processes, determining the productive ability of plants (Fig. 18).

Among the whole diversity of physiological criteria those physiological indexes which are closely connected with common plant resistance to stresses respond greatly to stresses, and besides they are methodically available.

According to Udovenko (1979), such criteria refer the permeability of cell membranes, water-osmotic cell regimes, levels of energy formation in cell, and also intensity of growth reactions as integral index of plant metabolism activity. Pollution conditions influence greatly nitrogenous and carbohydrate exchange, activity of amino acids (prolin), photosynthesis, transpiration etc. (Kondo).

Mamedov (1981) suggested to determine the coefficient of water-reserving capacity, which is equal to the ratio of watering to mass of discharged water in leaves after their withering. The higher this indexes the stronger plant resistance to unfavourable factors of the environments. The results indicated a tendency of increasing in the variants with mineral fertilizer application, biohumus and zinc on the biohumus of background. Water-holding capacity of leaves was higher in those variants in which the reduction of toxicological influence of polluted substances and the increasing of shoot increment volume were observed. A number of authors suggested that plant resistance to unfavourable factors of environments, including to ion toxicity, according to the output of electrolytes from leaves before and after stresses. The changes of membrane permeability are connected with absorption intensity and element distribution in plant organs. The higher the output of organic substances and electrolytes from leaf tissues the less toxicological influence of polluted substances on plants the more effective influence of studied doses and element combinations on absorption processes and transpiration of polluted substances into plants.

The obtained data on productivity are weakly connected with physiological indexes. The study of photosynthetic plant reaction growing on polluted soils shoved the high complexity of

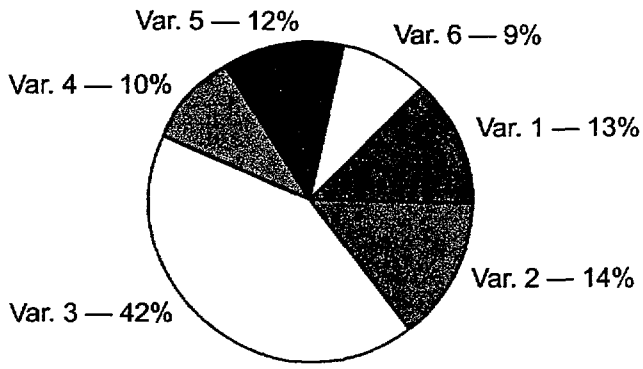


Fig 18. The total volume of shoots increment, cm^3.

1. NPK on colculated method.
2. Biohumus (B) 300 kg/ha.
3. $B+Zn_{40}$.
4. $B+Zn_{60}+Al_{100}+Mg_{900}$
5. $B+Zn_{40}+Al_{100}+Mg_{900}$
6. $NPK+Zn_{60}+Al_{100}+Mg_{900}$

organism reaction, determined by the integration of separate indexes of photo synthetic plant activity (Table 6). There is no straight dependence between photosynthesis intensity of leaf area unit with time unit and accumulation of plant biomass. Amirzhanov (1980) suggests to characterise quantity dependence of biological yields by the size and work of photosynthetic apparatus, considering quality tendency of photosynthetic process and characterise it by the equation of Nichiporovich:

$$Y\ biol. = (PhCO_2\ \ CIPh\ L)\ n \times 10^{-5}\ cent/ha$$

where Y biol. — total weight of dry biomass, $PhCO_2$ — intensity of photosynthesis, CIPh — coefficient of photosynthesis intensity, L — leaf area, n – number of days of vegetative period, 10^{-5} — the coefficient for recomputation of yield in centner/ha. The twenty four – hour increment of total biomass is determined by the formula:

$$I = P.P.Ph.\ «A»,$$

where I — increment, P.P.Ph. — pure productivity of photosynthesis.

In our experiment pure productivity of photosynthesis changed both according to experiment variants and in antagonistic cycle of plant development (Table 7).

Table 6.

The influence of cultivation of boron polluted soils on grape productivity

Soil	Variants	Increment volume of shoots, cm3/bush	Summary area of leaf surface,cm2 per bush	Biological* yield g/bush	PPPh,g/m2 in twenty-four hours	PhR, %
The first vegetation						
Light sierozem	NPK according to calculation	145	1811	15.5	0.30	0.001
With the excess	Biohumus 300 kg/ha (B)	295	2330	37.8	0.57	0.003
Of salts and	$B+Zn_{40}$	549	2842	38.1	0.47	0.003
Boron	$B+Zn_{60}+Al_{100}+Mg_{900}$	211	2687	30.9	0.40	0.002
	$B+Zn_{40}+Al_{100}+Mg_{900}$	252	3275	34.3	0.37	0.003
	$NPK+Zn_{60}+Al_{100}+Mg_{900}$	249	2772	21.4	0.27	0.002
The second vegetation						
-"-	NPK according to calculation	350	2008	92.8	1.62	0.008
	B	460	1988	123.5	2.16	0.011
	$B+Zn_{40}$	655	2798	186.0	2.33	0.016
	$B+Zn_{60}+Al_{100}+Mg_{900}$	403	2275	106.8	1.64	0.008
	$+Zn_{40}+Al_{100}+Mg_{900}$	434	2527	115.0	1.59	0.010
	$NPK+Zn_{60}\ Al_{100}\ Mg_{900}$	375	1688	99.5	2.06	0.008
The first vegetation						
Light sierozem	NPK according to calculation	460	1531	34.8	0.80	0.002
With the excess	B	166	4561	38.2	0.29	0.003
Of boron and	$B+Zn_{40}$	1031	3344	34.3	0.36	0.003
Salts	$B+Zn_{60}+Al_{100}+Mg_{900}$	94	2070	34.0	0.57	0.003
	$+Zn_{40}+Al_{100}+Mg_{900}$	152	2417	32.9	0.48	0.003
	$NPK+Zn_{60}+Al_{100}+Mg_{900}$	111	1223	25.9	0.74	0.003

The second vegetation						
-"-	NPK according to calculation	573	1951	143.8	2.58	0.012
	B	793	2366	210.3	3.11	0.018
	$B+Zn_{40}$	890	2814	236.0	2.94	0.021
	$B+Zn_{60}+Al_{100}+Mg_{900}$	534	2333	133.6	2.00	0.011
	$B+Zn_{40}+Al_{100}+Mg_{900}$	774	2299	205.2	3.12	0.017
	$NPK+Zn_{60}+ Al_{100}+ Mg_{900}$	386	2072	102.3	1.72	0.009

*Biological yield is the biomass increment of vegetative plant parts for the vegetation period.

Table 7.

Physiological indexes of grape bush development in vegetative experiment with meliorants on soils with different type of salinity.

Soil	Experiment variants	Transpiration of intensity mg/g	Watering, %	Coefficient of water-holding capacity	Concentration of cell juice, %	Relative electro-conductivity, %
The first vegetation						
Sierozem	NPK according to calculation	324.8	73.4	6.0	—	—
With the	B	260.5	75.1	9.5	12.2	—
Excess of	B+00+Zn_{40}	566.8	75.8	6.1	15.4	—
Salts and	B+Zn_{60}+Al_{100}+Mg_{900}	563.5	75.2	7.1	17.2	—
Boron	B0+Zn_{40}+Al_{100}+Mg_{900}	300.5	77.3	6.4	9.7	—
	NPK+Zn_{60}+Al_{100}+Mg_{900}	359.0	74.9	8.3	10.3	—
Sierozem	NPK according to calculation	292.0	76.0	8.6	13.5	—
With the	B	412.3	73.6	7.3	16.0	—
Excess of	B+Zn_{40}	554.8	73.0	6.5	12.2	—
Boron and	B+Zn_{60}+Al_{100}+Mg_{900}	612.0	74.1	6.2	7.7	—
Salts	B+Zn_{40}+Al_{100}+Mg_{900}	527.5	76.8	7.5	10.3	—
	NPK+Zn_{60}+Al_{100}+Mg_{900}	575.8	74.2	5.4	9.7	—
The second vegetation						
Sierozem	NPK according to calculation	800.6	75.1	4.8	9.7	68
With the	B	867.4	75.4	3.0	10.0	63
Excess of	B+Zn_{40}	769.4	75.6	3.4	10.8	63
Salts and	B+Zn_{60}+Al_{100}+Mg_{900}	858.1	75.5	4.0	11.4	74
Boron	B+Zn_{40}+Al_{100}+Mg_{900}	1004.0	73.7	2.9	11.0	76
	NPK+Zn_{60}+Al_{100}+Mg_{900}	865.5	72.4	3.4	11.4	92
Sierozem	NPK according to calculation	578.6	74.7	4.6	10.6	73
With the	B	1096.3	73.3	4.6	10.4	67

Excess of Boron and Salts	$B+Zn_{40}$	641.4	76.0	5.0	12.3	80
	$B+Zn_{60}+Al_{100}+Mg_{900}$	866.6	73.9	4.2	13.1	76
	$B+Zn_{40}+Al_{100}+Mg_{900}$	1438.8	77.8	4.2	11.7	82
	$NPK+Zn_{60}+Al_{100}+Mg_{900}$	714.7	76.4	5.0	12.0	83

P.P.Ph. with the increasing of plant age increased. During the first vegetation P.P.Ph. on soils with high excess of salts was higher in variant with humus application. On soils with high boron excess the variants with the application of mineral fertilizers and microelements on mineral fertilizer background were the best.

The analysis showed the very low and low degree of providing with elements of mineral nutrition in soils of high excess of salts and especially with nitrogen, phosphorus and potassium (Table 4). Therefore application of mineral, easily available for plants fertilizers optimized the regime of nutrition, increased the productivity of plants. During the period of the second vegetation, the highest P.P.Ph. was noticed in plant variants with biohumus application and also zinc on biohumus background. Recomputation of biological productivity to the area of leaf surface reflects actually formed correlation between biomass and leaf surface. In increment formation plastic substances from 2-year's bush parts may be involved, what increases the size P.P.Ph. In determination of vegetative mass the energy, discharged for consumption of root system and increment of perennial wood was not taken into account. Integrating index Ph.A.R. — (photoactive radiation) of plants is the coefficient of Ph.A (photosynthetic activity) use. Coefficiency of PhAR surves as a measure for relative level of solar energy used by plants. In vegetative experiment during two vegetations according to physiological state intensity of growth processes on PhAR for formation of biological yields the variant with Zn application of the amount of 40 kg/ha into soil on biohumus background — of 600 kg/ha. The positive results gives also biohumus application into soil especially during the season of the first vegetation (Table 7).

Soil reclamation influenced the quality and the quantity of soil solution composition.

The highest solid residues are noticed in variants with mineral fertilizer application (Table 8).

Table 8.

Chemical composition of filtrates, mg/l

Experiment variants	Anions					Cations					
	Cl	SO_4	HCO_3	H_3	No_3	Na	Ca	Mg	K	pH	Dry residues
Light Sierozems with high content of salts and middle amount of B.											
1. NPK according to calculation (control)	352	211	269	580	506	130	299	358	69	8.2	5540
2. Biohumus (B) 0,3 ton/ha	64	154	410	446	153	73	90	49	17	8.5	1520
3. B + Zn_{60} mg/kg of soil	119	654	264	508	158	165	275	83	18	8.4	2400
4. B + Zn_{60} Al_{266} Mg_{66} mg/kg of soil	87	884	298	650	79	115	243	262	20	8.4	1740
5. B + Zn_{140} AL_{233} Mg_{233} mg/kg of soil	114	863	261	452	57	174	196	245	24	8.4	3840
6. NPK + Zn_{160} Al_{266} Mg_{66} mg/kg of soil	133	884	277	632	242	199	319	468	45	7.6	5520
Light Sierosems with high boron content and middle amount of salts.											
1. NPK according to calculation (control)	386	250	303	1290	228	210	427	234	363	8.1	4800
2. Biohumus (B) 0,3 ton/ha	119	346	508	1462	306	340	274	161	240	8.2	4100
3. B + Zn_{60} mg/kg of soil	64	423	256	1432	359	230	116	143	245	8.5	2380
4. B + Zn_{60} Al_{266} Mg_{66} mg/kg of soil	68	749	361	922	311	250	311	137	160	8.4	2760
5. B + Zn_{140} Al_{233} Mg_{233} mg/kg of soil	60	1403	439	1268	239	225	354	294	278	8.2	4000
6. NPK + Zn_{160} Al_{266} Mg_{66} mg/kg of soil	179	692	264	988	285	180	434	234	205	8.2	3860

Mineral fertilizers penetrating into soil activated the processes of organic substance mineralization, increase the element availability, including toxicity substances. In variants with macrofertilizer application according to calculation solid residues increase in soils with excessive salt content by 3.6 times. In soils with boron excess, such changes were not observed. Here the highest content of solid residues is in variants with calculated NPK application. The application

of antagonist elements on biohumus background reduced the amount of firm residues in soils with the excess of salt content. Mineral fertilizers increasing availability of elements promote their leaching beyond the root zone layer and by that release soil from harmful substances. The intensification of mineralization processes, washing elements beyond the root zone, reduce potential and increase effective soil fertility. For maintaining the balance of organic substances under such conditions the application of mineral fertilizers should be conducted on the background of soil enrichment by the application of organic fertilizers.

The application of biohumus influences positively the microbiological soil activity, productivity of orchard agrocoenosis and consequently the process increasing of humification and accumulation of organic substances. In this case the process increasing of mineralization does not influence substance leaching beyond ownrooted soil layer. Organic substance ties the elements influencing the enhance of soil fertility. «Cl» leaching considerably increases the concentration of filtration water in mineral variants. By application of calculated NPK in variants with excess of salt content «Cl» content is 5.5 times higher in filtrates than in variants with biohumus and 3 times higher in soils with boron excess. Elements- antagonists applicated on the mineral fertilizers background reduce considerably chlor-ion in filtrates. Ontagonists applicated on biohumus background did not greatly influence the amount of firm residues but increased ion SO_4 content in filtrates, especially in soils with higher salt content (13 times).

On soils with higher boron content antagonist application increased ion SO_4 content by 6 times. The concentration of applicated elements was very important.

Higher content of ion sulfate was found out in variant with predominant application of magnesium sulfate. By biohumus application to soil, the leaching of HCO_3 was enhanced, the content of which in leachate with application of elements- antagonist can reduce.

Boron content in leachate remained high in all variants of the experiment. The common regularity was the increasing of boron content in lysimetr water of soil with excessive B content. The higher leaching of boron was noticed in variants with biohumus and zinc sulfate applications on biohumus background. Organic substance in less saline soils with high boron content provides its leaching from upper soil horizons.

Higher nitrogen (ion nitrate) is in water of variants with mineral fertilizers. Nitrogen content is especially low in soils with high salt content in variants with application of Zn, Al and Mg on

biohumus background. Elements bind nitrate-ion and transfer it to non-dissociation state. Leaching of NO_3 is 1.2 times greater in soils with high B content.

Na was more leachable in lysimeters with with higher boron content, though its stock in these soils is inferior to saline soils. By application of biohumus and microelements Na leaching increased.

Ca in leachate from soils with excessive boron content is 1.3 times greater than in leachate from saline salted soils. Calcium is greater when the soil was leached in variants with mineral fertilizer, and less-with biohumus.

The application of elements-antagonists promote increasing of Ca content in leachate especially by application of heigh doses of Zn, Al and Mg

K content in leachate of variants with microelements (Zn + Mg + Al) is low. Potassium is especially greatly leached from soil in variants with higher boron content.

Mineral fertilizers provide for mineralization of organic substance, element washing including toxic substances from ownrooted soil layers.

Cl is greatly leached in saline soils high in chloride- sulfate type of salinity. The application of mineral fertilizers in combination with excess irrigation for leaching will promote their cultivation-release from the most toxic CL. The application of mineral fertilizers into soils with excessive boron content is less effective. The application of elements-antagonists on mineral fertilizer background does not increase boron availability. For soils high in boron content the application of elements-antagonists on biogumus background gave the best results: they reduce the penetration of boron into plants. For revealing fertilizer influence on biological soil activity sterile flax linen, saturated with nitrogen salts (urea) in concentration of 0, 760, 720 mg/kg of active substance were put for 2 weeks into vessels of experiment on soil cultivation of boron pollution with salt excess. The changes of microbiological soil activity were not observed (Table 9).

In all experiment variants, the intensity of microbiological soil activity was at high level. High microbiological activity of soil and its stability according to variants of the experiment speaks for the efficiency of calculated methods of mineral fertilizer use at least in the respect of nitrogen.

Table 9.

Nitrogen influence on biological soil activity (balls)

Experiment variants	Nitrogen doses, mg/kg		
	0	360	720
Light sierozems with high content of salts and middle amount of B.			
1. NPK according to calculation (control)	4	4	4*
2. B	3	3	3
3. B+Zn_{60}, mg/kg of soil	3	3	3
4. B+Zn_{60}+Al_{266}+Mg_{66}, mg/kg of soil	3	4	4
5. B+Zn_{140}+AL_{233}+Mg_{233}, mg/kg of soil	3	4	4
6. NPK + Zn_{160}+Al_{266}+Mg_{66}, mg/kg of soil	4	4	5
Light sierozems with high content of boron and middle amount of salts.			
1. NPK according to calculation (control)	3	3	3
2. B	3	3	3
3. B+Zn_{60} mg/kg of soil	4	4	3
4. B+Zn_{60}+Al_{266}+Mg_{66} mg/kg of soil	5	5	5
5. B+Zn_{140}+AL_{233}+Mg_{233} mg/kg of soil	5	5	4
6. NPK+Zn_{160}+Al_{266}+Mg_{66} mg/kg of soil	4	4	5

* The evaluation of biological activity was conducted according to the change of colour degree of linens (summary amount of aminoacids) by 5- ball scale.

The second arrangement of linens into soil at the end of vegetation period showed that high microbiological soil activity preserve in variants with mineral fertilizer application and especially in the variant of joint application of macro-and microfertilizers (Table 10).

Table 10.

The change of biological soil activity depending on the means of soil cultivation, mkg/g of linen.

Experiment variants	Summary amount of aminoacids	
	strong B excess,, middle salt excess	strong salt excess,, middle B excess

1. NPK according to calculation (control)	688	775
2. B	325	325
3. B+Zn_{60},mg/kg of soil	362	160
4. B+Zn_{60}+Al_{266}+Mg_{66}, mg/kg of soil	712	438
5. B+Zn_{140}+AL_{233}+Mg_{233}, mg/kg of soil	175	425
6. NPK+Zn_{160}+Al_{266}+Mg_{66}, mg/kg of soil	1875	1400

On the basis of long-term experiments and observations on grapes Beredenko (1953) pointed out that accumulation process of harmful substances takes place especially energetic on soils with poor mineral nutrition. The shortage of nutrition is the reason of reduction in microbiological soil activity. The application of high-available optimal doses of mineral fertilizers into soil promoted the stimulation of the activity of microorganism vitality, increased photosynthetic activity of leaf apparatus. Appeared disproportion between intensity of microbiological processes in soil and grape productivity is explained by antagonistic peculiarities of elements, their ability to blockade polluted substances in the limits of definite index amplitude of soil fertility, including microbiological soil activity.

The conducted investigations convincingly proved that the melioration of polluted soils should be conducted on the background of calculated mineral fertilizers providing optimal regimes of plant nutrition. In this respect the use of biohumus is considered as catalyst, intensifying the availability of elements- antagonists and increasing their antitoxicological effect. The achievement on mineral nutrition optimization at the expense of biohumus is not economically effective because of its high cost. According to the obtained preliminary results, using manure or green manure crops will gives positive results.

In 1999 the investigations continued in application, laboratory and lysimeter experiments on revealing elements-antagonists of salts and boron, determination of optimal correlations and concentrations of elements, optimising plant nutrition and increasing soil fertility. In application experiment optimal concentrations of elements-antagonists were determined, in laboratory distinguished in the experiments elements on physiological state, growth and productivity of plants was studied in laboratory and lysimeter experiments. The obtained research results were examined on the vineyard in the South of Kazakhstan, growing on salted soils with boron excess.

The study of action character of elements-antagonists on intensity of microbiological processes showed that the concentration of elements distinguished in former experiments changed very little after two vegetative periods. As in former years optimal composition and concentration of elements differed depending on soil properties. For soils with high excess of boron and mean content of salts the highest intensity of microbiological processes was noticed under application of $MgSO_4$ in doses 1500, $Al_2(SO_4)_3$ — 800, $ZnSO_4$ — 60; for soils with high excess of salts and mean content of boron — 800, 100 and 60 accordingly (Table. 11).

Table 11. Aminoacid content on linens treated by increasing element concentrations and arranged in saline soil with boron excess in application experiment (1999).

Elements		$MgSO_4$		$Al_2(SO_4)_3$	$ZnSO_4$	KCl	$CaCl_2$
Soil with high excess of salts and mean boron content							
Element doses, mg/kg	100	100	60	50	250		
Aminoacid content, mg/kg		450	950	525	525	800	
Element doses	800	800	180	100	500		
Aminoacid content		525	950	350	1025	475	
Element doses	1500	1000	300	150	1000		
Aminoacid content		875	750	675	1050	650	
Element doses	3000	3000	—	300	2000		
Aminoacid content		575	750	—	775	200	
Soil with boron excess and mean salt content							
Element doses	100	100	60	50	250		
Aminoacid content		1400	1870	725	1100	1100	
Element doses	800	800	180	100	500		
Aminoacid content		1650	600	600	1025	1575	
Element doses	1500	1000	300	150	100		
Aminoacid content		925	975	725	1450	875	
Element doses	3000	3000	—	300	2000		
Aminoacid content		1450	500	—	450	850	

Optimization of mineral nutrition was reached by optimal content of elements and their optimal correlation. Optimal correlation of mineral nutrient elements may be reached on different levels of soil providing by elements of mineral nutrition under excessive content in soil of one and several elements optimal correlation is reached by the application of deficient elements. When optimal correlation of elements in soil is reached and their total influence on a plant does not reach toxicological border the optimization problem under concrete conditions of growing may be consided to be solved. Optimal correlation of elements in soil not only provides for high and regular yield of agricultural crops but is a guarantee of high quality of plant-growing products. On weak and mean polluted soils the balance of mineral nutrition of plants may be reached by the

optimization of correlations of mineral nutrition biophill elements. The more biophyllous elements take part in the process of optimization of correlations the better final effect.

On heavy pollutes soils for the reachment of optimal correlation it is necessary to applicate such amount of substances which, as a rule causes toxicological effect on plants and even may lead to their dying-off. To reach the positive results under such conditions it is necessary to applicate one or several elements, not increasing the concentration of soil solution to the critical border beyond which plant depression begins and then their dying off. In this case the applicated elements are used as antagonists and they inhibit negative influence of salts and boron on plants.

For revealing the character of element interaction and their integral influence on soil fertility and grape the influence of distinguished elements-antagonists on microbiological soil activity was studied. The determination of microbiological soil activity was conducted in laboratory many factor experiment, including 8 doses of each element (Zn, Mg and Al). The experiment was laid out on scheme, given by V. N. Peregudov and T. I. Ivanova (1972). Revealing of optimal doses and element combinations were conducted by the method of conditional factor, allowed from full factor of experiment scheme, including 729 variants, to select 81. For conditional factor was taken element combination in doses 0, 1 and 2 (doses 0, 3 and 6 in combination 000, 111 and 222). For threefold dose it was taken optimal element combination, obtained in application experiment:

Zn	0	30	60	90	120	150	180	210	240	
Al	0	50	100	150	200	250	300	350	400	
Mg	0	400	600	1200	1600	2000	2400	2800	3200	mg/kg

The data of laboratory experiment allowed to reveal optimal combinations and concentrations of elements-antagonists of the tested soil varieties.

For soils with high salt excess and mean boron content:

Zn_{140}

Zn_{160} Al_{266} Mg_{66}

Zn_{160} Al_{233} Mg_{233}

For soils with high boron excess and mean salt content:

Zn_{140}

Zn_{160} Al_{266} Mg_{66}

Zn_{90} Al_{60} Mg_{233}

On the basis of application and laboratory experimental results the optimal doses of meliorants were repeatedly applicated in vegetative vessels and lysimeters in June, 14, 1999. The influence of elements-antagonists on grape productivity was determined.

In vegetative experiment the study of photosynthetic response of plants growing on polluted soils showed the expressed reaction of organism to element application (Table 12).

Table 12. Physiological indexes of grape bush development in vegetative experiment (1999).

Experiment variants	Transpiration intensity, mg/g	Watering, %	Coefficient of water-holding capacity	Concentration of cell juice, %	PPPh, g/m^2 24 hours	PhAR, %
Sierozem with salt and boron excess						
NPK according to calculation (control)	873	76	6,9	12,3	0,30	0,03
Biohumus 10 g/kg soil (B)	921	77	7,0	6,8	0,30	0,03
B+Zn_{140}, mg/kg	914	77	5,8	12,2	0,27	0,05
B+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	1166	77	6,3	11,3	0,26	0,02
B+$Zn_{160}AL_{233}Mg_{233}$, mg/kg	1193	75	5,6	13,0	0,24	0,02
NPK+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	407	75	11,6	12,7	0,25	0,03
Sierozem with boron and salt excess						
NPK according to calculation (control)	838	70	6,4	14,0	0,40	0,05
Biohumus 10 g/kg soil (B)	1168	77	5,6	10,9	0,36	0,05
B+Zn_{140}, mg/kg	838	75	5,5	12,9	0,35	0,04
B+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	898	74	6,4	14,8	0,36	0,05
B+$Zn_{90}AL_{60}Mg_{233}$, mg/kg	943	78	7,9	14,4	0,39	0,04
NPK+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	1172	75	10,6	14,3	0,30	0,03
HCP					0,10	0,01
%					4,1	4,4

The highest coefficient of the use of photosynthesis active radiation (PhAR) was observed in the variant with application of 140 mg/kg of zinc on the biohumus background. In the variants with microelements application the highest and pure productivity of photosynthesis (PPPh) was found.

The analysis of filtrated waters showed that more elements are leached in the variants with the application of nitrogen, phosphorus and potassium according to calculated method. In the filtrate a considerable amount of ion SO_4 by 127 mg-eq/l and in heavy polluted soils and B — by 13.5

mg-eq/l, rather less, Cl by 78 mg/l and HCO_3 by 8.6 mg-eq/l were found out. The nitrogen content in filtrate was mainly noticed in variants with the application of full mineral fertilizers. In kation part Ca by 91, Mg by 102.5 mg-eq/l, less Na were leached. The application of mineral fertilizers promotes soil release from boron and readily soluble salts of chlorides and sulphates, what may be used in polluted soil leaching, influences the biological grape productivity (Table 13).

Table 13. The composition of filtrated waters in vegetative experiment, mg-eq/l

Variants	Cl	SO_4	HCO_3	NO_3	B	Na	Ca	Mg	K
Soils with high boron excess and mean salt content									
NPK according to calculation (control)	71,5	86,5	2,9	3,6	9,7	27,5	73,5	43,5	31
Biohumus 10 g/kg soil (B)	12,9	20,5	4,6	8,5	8,7	19,5	18,4	13,3	3,4
B+Zn_{140}, mg/kg	18,0	63,0	5,1	4,4	10,7	22,8	36,8	36,7	5,5
B+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	17,5	109,0	8,6	8,8	13,0	21,0	44,2	63,5	8,0
B+$Zn_{160}AL_{233}Mg_{233}$, mg/kg	12,9	181,5	7,1	4,4	13,5	44,5	38,5	124,5	12,0
NPK+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	78,0	86,5	3,2	6,4	11,7	27,0	91,0	57,5	12,5
Soils with high salt excess and mean boron content									
NPK according to calculation (control)	72,5	94,5	4,25	8,5	8,1	26,5	74,5	42,0	42,0
Biohumus 10 g/kg soil (B)	12,2	22,5	4,2	5,8	10,1	14,5	21,4	15,4	3,4
B+Zn_{140}, mg/kg	19,5	66,5	8,3	10,0	12,5	5,2	51,0	29,5	14,5
B+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	12,8	105,0	7,0	5,3	12,5	35,5	46,4	55,5	6,5
B+$Zn_{90}AL_{60}Mg_{233}$, mg/kg	15,6	127,0	8,6	4,8	12,5	50,0	32,8	102,5	13,3
NPK+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	74,0	83,0	3,5	5,8	8,1	27,0	78,5	57,0	11,3

Leaf analysis on the content of microelements, boron, zinc, magnesium and calcium showed that the application of NPK increased N and P content in leaves (Table 14).

Table 14. The content of macro- and microelements in grape leaves of the variety Parlet depending on soil reclamation methods in vegetative experiment (1999)

Variants	N, %	P_2O_5, %	K_2O, %	B, mg/kg	Zn, mg/kg	MgO, mg/kg	CaO, mg/kg
Sierozem with salt and boron excess							
NPK according to calculation (control)	1,8	1,1	1,1	40,2	31,6	0,73	4,3
Biohumus 10 g/kg soil (B)	1,4	0,89	1,15	28,1	33,4	0,90	4,7
B+Zn_{140}, mg/kg	1,3	0,78	1,13	16,0	36,4	1,27	4,0
B+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	1,3	0,78	1,06	16,2	52,4	1,36	4,0
B+$Zn_{160}AL_{233}Mg_{233}$, mg/kg	1,3	0,72	1,09	26,8	41,7	1,16	4,4
NPK+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	1,9	0,76	1,13	31,1	43,5	1,08	4,2
Sierozem with boron and salt excess							
NPK according to calculation (control)	2,1	1,06	1,33	42,0	26,8	0,93	3,9
Biohumus 10 g/kg soil (B)	1,9	1,03	1,33	34,2	30,9	1,2	3,7
B+Zn_{140}, mg/kg	1,9	1,47	1,38	21,0	45,9	1,31	3,5
B+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	1,7	1,02	1,37	26,8	42,8	1,26	3,5
B+$Zn_{90}AL_{60}Mg_{233}$, mg/kg	2,1	1,12	1,30	28,1	50,1	1,76	3,3
NPK+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	2,1	0,86	1,56	28,1			

Due to high content of potassium in studied soils, potassium application did not essentially influence its content in leaves, especially in the variant with the application of hightened doses of zinc, aluminium, magnesium on the biohumus background. The inverse correlation dependence was observed between the content of zinc and boron in leaves. In optimal variants ($B+Zn_{140}$ and $B+Zn_{160}Al_{233}Mg_{233}$ mg/kg) higher Zn contents in leaves and lower B content was found out. The application of elements-antagonists of salts and boron did not essentially influence Ca content in leaves and increased Mg content. Microelement content in shoots is more equal, though here the tendency of increasing nitrogen and phosphorus in variants with the application of nitrogen, phosphorus and potassium (Table 15)

Table 15. The content of macro- micro elements in grape shoots depending on soil reclamation methods in vegetative experiment (1999)

Variants	N, %	P_2O_5%	K_2O, %	B, mg/kg	Zn, mg/kg	Mg, mg/kg	Ca, mg/kg
Sierozem with salt and boron excess							
NPK according to calculation (control)	0,8	0,56	0,70	7,8	32,9	0,57	3,2
Biohumus 10 g/kg soil (B)	0,4	0,49	0,98	5,5	48,7	0,61	2,8
$B+Zn_{140}$, mg/kg	0,4	0,48	0,75	6,0	55,0	0,76	2,7
$B+Zn_{160}Al_{266}Mg_{66}$, mg/kg	0,4	0,39	0,76	6,5	57,2	0,60	2,2
$B+Zn_{160}AL_{233}Mg_{233}$, mg/kg	0,5	0,48	0,97	5,2	65,4	0,58	2,4
$NPK+Zn_{160}Al_{266}Mg_{66}$, mg/kg	0,4	0,46	0,91	6,7	65,0	0,53	2,3
NPK according to calculation (control)	0,37	0,63	0,96	8,1	45,5	0,38	1,9
Biohumus 10 g/kg soil (B)	0,26	0,63	0,86	5,4	44,9	0,37	2,3
$B+Zn_{140}$, mg/kg	0,32	0,66	1,08	3,7	69,3	0,42	2,1
$B+Zn_{90}AL_{60}Mg_{233}$, mg/kg	0,37	0,54	0,94	5,2	70,1	0,37	1,6
$B+Zn_{160}AL_{233}Mg_{233}$, mg/kg	0,25	0,67	0,84	6,5	61,9	0,33	2,1
$NPK+Zn_{160}Al_{266}Mg_{66}$, mg/kg	0,25	0,54	0,82	5,2	65,6	0,47	2,1

was also observed. Boron content in experimental variants was lower than in control and zinc content was higher.

Leaf analysis may be enough reliable index of the level grape nutrition optimisation on salted soils with the excess of boron content.

In lysimeter experiments the true yield addition was found out in variants with the application of selected doses of elements-antagonists of salts and boron (Tables 16 and 17).

Table 16. The elements of grape bushes fruitbearing of the variety Aligote depending on melioration means of salted soils with boron excess (lysimeter, 1999)

Variants	Buds left, number/bush	Wintering of buds, number/bush	Shoot development, number/bush	The number of fruitbearing shoots, number/bush	The number of inflorescents, number/bush	Yield coefficient	Fruit-bearing coefficient
Sierozem with salt and boron excess							
NPK according to calculation (control)	117	52,1	64	26	42	0.66	1.62
Biohumus 10 g/kg soil (B)	118	53,4	68	27	44	0.65	1.63
B+Zn_{140}, mg/kg	118	60,1	71	30	46	0.65	1.53
B+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	117	50,0	65	35	51	0.78	1.46
B+$Zn_{160}AL_{233}Mg_{233}$, mg/kg	115	58,3	72	27	43	0.60	1.59
NPK+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	118	59,3	70	26	40	0.57	1.54
Sierozem with boron and salt excess							
NPK according to calculation (control)	116	54,3	68	24	41	0.60	1.62
Biohumus 10 g/kg soil (B)	119	53,8	72	34	52	0.72	1.53
B+Zn_{140}, mg/kg	116	57,7	67	26	44	0.66	1.68
B+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	118	50,0	61	28	43	0.70	1.54
B+$Zn_{90}AL_{60}Mg_{233}$, mg/kg	118	46,6	61	30	48	0.79	1.60
NPK+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	117	53,0	66	24	38	0.57	1.58

Table 17. The productivity of grape bushes of the variety Aligote depending on melioration means of salted soils with boron excess (lysimeters, 1999)

Experiment variants	The number of shoots, number/bush	Total increment of shoots, cm/bush	The number of leaves, number/bush	The area of leaf surface, m^2/bush	The number of clusters, number/bush	The yield, cent/ha
Sierozem with salt and boron excess						
NPK according to calculation (control)	64	4083	833	8.7	40	144.0
Biohumus 10 g/kg soil (B)	68	4386	848	9.0	39	140.2
B+Zn_{140}, mg/kg	71	4901	859	8.57	44	158.4
B+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	65	5494	1012	9.8	46	165.6
B+$Zn_{160}AL_{233}Mg_{233}$, mg/kg	72	5494	1025	11.54	40	144.0
NPK+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	70	4543	840	8.52	37	124.2
Sierozem with boron and salt excess						
NPK according to calculation (control)	68	4565	953	9.82	38	136.8
Biohumus 10 g/kg soil (B)	72	4407	850	8.0	48	172.7
B+Zn_{140}, mg/kg	67	4600	869	8.81	42	151.2
B+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	61	4721	842	9.26	39	140.2
B+$Zn_{90}AL_{60}Mg_{233}$, mg/kg	61	6321	1180	13.3	46	165.6
NPK+$Zn_{160}Al_{266}Mg_{66}$, mg/kg	66	4505	810	6.65	35	125.8

The application of soluable salts of zinc, aluminium and magnesium in ecologically safe doses optimised plant nutrition regime on soils with boron pollution. In optimal variants the percent of alive grape buds is higher, more shoots and inflorescences developed on grape bushes. The application in polluted soils of optimal concentrations of elements-antagonists not only increase soil fertility and improve plant nutrition regimes but increases its tolerance to unfavourable factors of environments in the wintering period, what is very important in the culture of bent and uncovered vineyards. The culture of uncovered vineyards in Kazakhstan is not developed

because vines are not enough resistant to low winter temperatures. The increasing of grape winter-hardiness is one of the aspects in the elaboration of labour-saving technology of grape growing in southern regions of the Republic.

In the experiments on the reclamation of boron pollution soils with the excess of readily-soluable salts the highest melioration effect is observed in the application of elements-antagonists together with organic substances on the background of optimal nutrition regimes and plant irrigation.

Table data showed that the influence of elements-antagonists on microbiologiical activity of soils is vividly revealed in the presence of organic substances. The soils in the experiments are high-calcareous. The CO_2 content in carbonates in upper horizons is 6.5 and in low — more than 7%, water Ph is 8.0 and more percent, humus content is low. Applicated in such soils zinc, forming calcium zincates, falls in deposit and becomes little active; in the presence of organic substances its activity considerably increases. The increasing of element activity due to biohumus is economically little-effective because of its high price. The experimental data showed that biohumus may be successfully replaced by menure or green manure (Fig. 19).

On irrigated sierozems under great heat tension high immobilisation intensity of nutrient substances, especially of nitrogen is noticed. Nitrogen in soil is to a great extent subjected to transformation processes and its losses are very high (G. Guchsherov, 1969, V. Rankov a. o., 1966). Applicated in sierozem soils organic substance is rapidly mineralised, increasing non-productive losses of nutrition elements, what creates additional difficulties to split and frequent application of small doses of organic fertilizers as the period of system contact: organics-meliorants on sierozem soils is short. The use of inhibitors in nitrification and denitrification allows to preserve nitrogen in soil with strongly expressed nitrification activity and artificially to regulate its biological immobilisation by means of purposeful application of organic substances with given ratio of carton to nitrogen (Vaikova-Raikova Zh. a. o., 1986). Positive results on the increasing of process reduction of organic substance mineralization were obtained by the growing of winter rye as a green manure crop or by the application of reed, growing in a considerable amount on hydromorphic soils of sierozem zone in the south of Kazakhstan. Organic mineralization with high ratio of carbon to nitrogen develops less intensively and for longer period.

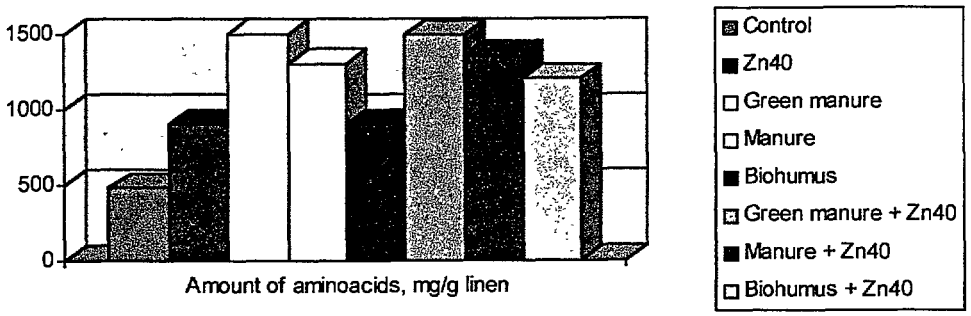


Fig. 19. The influence of organic substances and microelements on biological soil activity

Application, vegetation and lysimeter experiments showed that the application of Zn_{140}, $Zn_{160}Al_{266}Mg_{233}$ and $Zn_{160}Al_{233}Mg_{233}$ into soil with high excess of salts and mean content of boron and the application of Zn_{140}, $Zn_{160}Al_{266}Mg_{233}$ and $Zn_{90}Al_{233}Mg_{233}$ zinc of 140 mg/kg into soil with high excess of boron and mean content of salts proviide for the increasing of soil fertility and grape productivity. From all variants the most simple and available for the use in production is the variant with the application of zinc in the amount of 140 mg/kg, what was confirmed in field experiments.

The obtained results of application, laboratory and lysimeter experiments were tested in field experiments. Before planting grape seedlings during two hours were kept in the solution of zinc sulphate in concentration from 0.2 to 2.0% with the addition of 15 kg of manure in 100 l of solution. The best results were obtained when the plantings were kept in solutions with the concentration of 1.6 and 0.8% of zinc sulphate. Rooting of plantings in these variants was 80—90% and the increment was 93—141 cm per bush (Table 18).

Table 18. Rooting and increment of grape plantings depending on the methods of preplanting treatments of plants by zinc sulfate solution (1999)

Zinc concentration, %	Rooting, %	Increment, cm/bush
2—3	20	27
1	80	73
0,8	90	93
0,4	70	141
0,2	20	56
Control (without treatment)	50	41

Positive results on the melioration of salted soils with boron excess under grape plantations gave the application of 40 t/ha manure with placement in irrigated furrows of zinc sulphate according to the calculation of 40—60 kg/ha of active substance or growing of green manure and

ploughing under them by the following application of zinc in irrigated furrows, irrigation and covering irrigated furrows (Tables 19, 20, 21).

Table 19. the influence of meliorants on grape yield of the variety Terbash on light-salted soils in field experiment (1999)

Variants	Total increment of shoots, cm/bush	Leaf number, number/bush	The area of leaf surface m^2/bush	The number of clusters, number/bush	Yield, kg/bush	Percent to control
Control	3738	781	8.0	31	4,2	100
Green manure + NPK	4216	812	7.6	46	6,2	147
Green manure + Zn_{40} kg/ha	7137	1346	13.6	65	8,8	209
Green manure + Zn_{60} kg/ha	7364	1312	14.4	61	8,2	195

Table 20. The influence of meliorans on grape yield of variety Terbash on heavy-salted soils

Variants	Total increment of shoots, cm/bush	Leaf number, number/bush	The area of leaf surface m^2/bush	The number of clusters, number/bush	Yield, kg/bush	Percent to control
Control	983	200	2.1	10	1.3	100
Green manure + NPK	1585	306	3.2	14	1.9	146
Green manure + Zn_{40} kg/ha	1815	319	3.2	16	2.2	169
Green manure + Zn_{60} kg/ha	2035	375	3.6	17	2.3	176

Table 21. The influence of zinc, applicated on the manure background, on grape productivity on middle-salted soils in field experiment (1999)

Variants	Total increment of shoots, cm/bush	Leaf number, number/bush	The area of leaf surface m^2/bush	The number of clusters, number/bush	Yield, kg/bush	Percent to control
Control	7031	1469	15.1	58	7.9	100
Manure 40 t/ha	7453	1328	14.6	62	8.3	105
Manure + Zn_{40} kg/ha	9975	1182	19.1	91	12.3	155.6
Manure + Zn_{60} kg/ha	10237	1824	20.1	84	11.4	144.3

Reclamation of salted soils with boron excess did not negatively influence yield quality. The differences on the content of zinc and boron in leaves and berries of grapes in variants of the experiment were not significant. Zinc accumulation in leaves and especially in fruits was not noticed in the year of its application (Table 22). The proposed technology on melioration of salinity soils with the excess of boron increases soil fertility and grape yield by 1.5—2.0 times without decreasing fruit quality.

Table 22. The content of zinc and boron in grape leaves and fruits in field experiment, mg/kg (1999)

Experiment variants	Content in leaves		Content in fruits	
	Zn	B	Zn	B
Control	17.3	77.4	7.4	45.7
Green manure	18.0	62.1	8.6	50.3
Green manure +Zn_{40} mg/kg	18.9	84.3	5.4	65.6
Manure	20.8	43.4	4.1	49.8
Manure + Zn_{40} mg/kg	25.1	48.6	4.5	45.2

CONCLUSION

The main source of boron in the studied soils is primary and/or secondary boron minerals existing in the soils.

The application of zinc in the amount of 40 kg/ha on biohumus background of 600 kg/ha into saline soils high in boron boron content, the optimization of nutrition regimes and irrigation of grapes all decrease the toxicity effects of boron and increases grape productivity.

LITERATURE

Black C.A. 1965. Methods of Soil Analysis. Part 1. American Society of Agronomy. WI.

Bingham F.T., A.W. Margh, R. Bramson, R. Miller, and G. Ferry. 1972. Reclamation of salt-affected high boron soils in western Kern County. Ilgardia 11: 195-211.

Glusherov G. Microbiology. Sofia, 1969, 118 p.

Hoffinan G.I. 1980. Guidelines for the reclamation ofsalt-affected soils. G.A. O'Connor, (ed.). 2nd Inter-America conf. on Salinity and Water Management Technology, Zuarez, Mexico 11-12 Dec. 1980. pp.49-64.

Keren R. 1996. Boron. In: D.L. Sparks (ed.) Methods of Soil Analysis. Part 3. Chemical Methods. SSSA Book Series 5. Madison, WI. pp 603-626.

Keren, R. , and F.T. Bingham. Boron in water soils and plants. A review chapter in: Advances in Soil Science. (B.A. Stewart, ed.) pp. 229-276.

Morin, J. , S. Goldberg and I. Saginer. 1967. Arairtfall simulator with a rotating disk. Trans. Am. Soc. Agr. Eng. 10: 74-79.

Peregudov V. N., Ivanova T. I. Some peculiarities of planning and mathematical working up of the data on many-variant experiment on the study of the regularity of fertiliser action. Agrochemistry, 1972, No. 7, p. 119—130.

Rankov V. a. o. Agrochemistry. Acad. Sci. USSR, 4, 1966. 90 p.

Rhoades *I.D.,* R.D. Ingudson and I.T. Hatcher. 1970. Laboratory determination of leachable soil boron. Soil Sci. Soc. Am. I. 34:938-941.

Voinova-Raikova, V. Rankova, G. Ampova. Micro-organisms and fertility. Moscow, 1986. 118 p.