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PLANT GROWTH, METABOLISM AND ADAPTATION IN RELATION TO STRESS CONDITIONS:
XXIII. SALINITY-BIOFERTILITY INTERACTIVE EFFECTS ON GROWTH, CARBOHYDRATES AND PHOTOSYNTHETIC EFFICIENCY OF *Lactuca sativa* TRANSPLANTS

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ABSTRACT

Addition of a recommended dose of phosphorein biofertilizer into salinized soil, induced significant increases in all growth and reproductive parameters determined in growing lettuce plants throughout the entire period of the experiment. On the other hand, fertigation of such sodic salty soil with a recommended dose of nitrobein biofertilizer, induced slight, if any decreases, in growth and reproductive parameters at vegetative, flowering and fruiting growth stages. The contents of carbohydrates fractions as well as the pigment contents and the activity of PS II, of salinized lettuce plants fertigated with phosphorein biofertilizer, were increased throughout the three successive growth stages, above the control levels. On the other hand, with nitrobein biofertilizer slight, if any changes, in all metabolites determined, throughout the entire period of the experiment were obtained. Strong positive and negative correlations were observed between the changes in all growth and reproductive parameters and the changes in all metabolites determined in salinized lettuce plants fertigated with phosphorein and nitrobein, respectively.

Keywords: lettuce, salinity, nitrobein and phosphorein biofertilizers, growth, carbohydrates, pigments, PS II activity.

INTRODUCTION

Salinity is one of the major abiotic stresses that affects crop productivity and quality. Since salinity affects most aspects of plant physiology, growth and development (Borsani *et al*., 2003), plant response to salinity is one of the most widely researched subjects in plant physiology. Various crops show different sensitivities to different salinity levels. Plants are generally divided into four salinity rating groups: sensitive, moderately sensitive (lettuce), moderately tolerant, and tolerant (Jungklang, 2005).

Lettuce is an important leafy vegetable crop in Egypt. It is considered as an excellent nutritive source of minerals and vitamins as it is consumed as fresh green salad. Crop with such promising potentialities for local markets, would necessitate much research for improving its production quantity and quality (El-Bialey, 2005).

In Egypt, soil fertility is diminishing gradually due to soil erosions, loss of nutrients, accumulation of salts and other toxic elements, water logging and unbalanced nutrient compensation (Shehata and El-Khawas, 2003). Microbiological fertilizers are considered as an important part of environment friendly sustainable agricultural practices (Shehata and El-

Khawas, 2003). Biofertilizers include mainly the nitrogen fixing, phosphate solubilizing and plant growth-promoting microorganisms (Goel *et al.,* 1999).

Applying phosphate biofertilizers (phosphorein) to soil increased soluble phosphate, plant growth, dry matter, protein and N and P contents of maize plant (El- Sawah *et al*., 1995). Nitrogen supply is a key-limiting ingredient in crop production in many African countries. It is often not available and/or beyond the reach of many poor farmers, especially those in rural areas. The beneficial effect of bio-N-fertilizers application is the improvement of nitrogen contents (Shehata and El-Khawas, 2003), as well as the improvement of the physical and chemical properties of the yield (Ranganathan and Selvaseclan, 1997). In this work, the possibility of multification of salt stress by phosphorein and nitrobein biofertilizers was investigated.

MATERIALS AND METHODS

Pure strain of *Lactuca sativa* var. baladi transplants (25-d-old) were kindly supplied by the Horticulture Research Centre, Ministry of Agriculture, Giza, Egypt. Analytical grad chemicals were used throughout this investigation.

Of Egyptian biofertilizers commonly used with vegetable crops for increased production and improvement of quality, only two were chosen, namely: phosphorein (containing P dissolving bacteria; *Bacillus megatherium* var. phosphaticum) and nitrobein (containing N fixing bacteria; *Azospirillum sp.* and *Azotabacter sp.*). These were kindly supplied by Soil Fertility Sector at Mansoura, Agriculture Research Center, Ministry of Agriculture, Giza, Egypt.

ANALYTICAL METHODS

Estimation Of Carbohydrates.

The method of extraction of different carbohydrate fractions used in this investigation was patterned after those adopted by Younis (1963) and Handel (1968). Glucose was estimated in the ethanolic extract using the o-toluidine procedure of Fertris (1965). Sucrose was determined by first degrading reactive sucrose present in 0.1 cm^3 extract with 0.1 cm^3 5.4 N KOH at 97 ^{0}C for 10 min. Three cm^3 of freshly prepared anthrone reagent [150 mg anthrone + 100 cm^3 72% (w/w) H_2SO_4] were then added to the cooled reaction products and the mixture was heated at 97 ^{0}C for 5 min, cooled and the developed colour was read at 620 nm, using spectrophotometer. Polysaccharides in the present study was determined by the method of Thayermanavan and Sadasivam (1984).

Estimation Of Photosynthetic Parameters

Determination of pigments

The photosynthetic pigments, chlorophyll a (Chl a), chlorophyll b (Chl b), and carotenoids (Cars), were determined at the three stages (vegetative, flowering and fruiting) of plant growth, following the widely used spectrophotometeric method as recommended by Metzner *et al.* (1965).

Estimation of Photosynthetic activity (PS II)

An assay that measures the change in absorbance of a reaction mixture containing DCPIP can demonstrate the activities of photosynthesis (Arnon, 1949 and Trebest, 1972). In this assay, the degree of reduction of DCPIP is determined by measuring the change in absorbance of light at 600 nm with a spectrophotometer. The assay reaction mixture for determination of PS II activity contained 200 mM-Na phosphate (pH 7.2), 2 mM-$MgCl_2$ and 0.5 mM 2,6-DCPIP. A calibration curve in terms of micromoles of dye reduced (Dean and Miskiewicz, 2003) was made using 2,6-DCPIP range between 10-50 µM in the reaction mixture (4 cm^3). A linear relation between the concentrations of 2,6-DCPIP and the optical density readings was obtained.

RESULTS AND DISCUSSION

Time course experiment.

A large-scale experiment , carried outdoor under normal day and light conditions, was designed so as to study the effects of four different levels of NaCl, namely: 4 mmhos, 6 mmhos, 8 mmhos and 10 mmhos; each level being used either alone or in combination with a recommended dose of each of the attempted biofertilizers, namely: phosphorein and nitrobein. Thus, 65 pots, divided into 13 groups (each of five pots) were used. One of these groups was left without treatment to serve as water control and the other 12 groups were separately treated with each of the four NaCl levels either alone or in combination with the recommended dose of one of the biofertilizers. Thus, a total of 13 treatments representing all planned possible combinations of salinity levels and biofertilizers were penta-replicated in a completely randomized design.

Uniformly-sized groups of 25-d-old lettuce (*lactuca sativa* cv. Baladi) transplants were selected. The transplants were washed thoroughly with tap water and then transplanted in a mixture of clay-loamy soil (2:1, v/v) in pots (30×28×26 cm). The clay-loamy soil, obtained from the Agriculture Research Station of Mansoura, Dakahlia Governorate, was taken from the upper 30 cm arable layer. All pots contained equal amounts of homogeneous soil (8 Kg) in which eight to nine lettuce transplants were planted and given one week for establishment in the soil. That was followed, at an appropriate time, by thinning so as to leave five plants/pot for experimentation.

In all cases, treatment of lettuce transplants with NaCl and the biofertilizers was carried out after one week from the date of transplantation. Thus, the appropriate amounts of NaCl and the recommended dose for each of the biofertilizers used were calculated and added to each pot with irrigation water. All pots were irrigated with tap water, every three days, to maintain the soil at the field capacity throughout the experiment for control as well as for the variously treated plants; super phosphate was applied with irrigation water as 0.8 g/pot every three weeks.

Samples were taken after 25, 122, and 150 days from the date of transplantation; representing the vegetative, flowering and fruiting stages, respectively. Sampling was made in a way so as to include all plants allotted for each treatment in the five pots. Samples were used for determination of growth parameters (length of root, length of shoot, leaf area, number of flowers, number of fruits, fresh and dry mass and water content), carbohydrate content and photosynthetic parameters (pigment content, photosynthetic activity (PS Π).

It should be mentioned that the results from analyses were remarkably close; thus only the mean values will be presented in the corresponding tables and figures. The data presented were statistically analyzed, and comparison among means was carried out by calculating the least significant difference (L.S.D.) at 5% level (Snedecor and Cochran, 1980). The correlation coefficients between the growth parameters and the various metabolites were also carried out.

1- Changes in growth parameters.

The results herein reported show that, the values of the different growth and reproductive parameters (root length, shoot length, leaf area, number of flowers, number of fruits, fresh and dry mass and water content) of *Lactuca sativa* maintained throughout the vegetative, flowering and fruiting growth and developmental stages, appeared to decrease progressively and significantly with an increase in concentration of the administered NaCl, as compared with control levels (Table 1).

Addition of the recommended dose of each of the two biofertilizers (phosphorein and nitrobein) to the variously salinized lettuce plants induced the following changes:

a- Phosphorein induced significant increases in all growth and reproductive parameters determined, throughout the entire period of the experiment; the magnitude of response being most pronounced with the lowest concentration (4 mmhos NaCl) of salinity (see table 1). The calculated percent improvement for the various growth parameters as well as for the number of flowers and fruits per plant are found in table 1.

b- Addition of nitrobein appeared without any beneficial effect on all growth and reproductive parameters determined, Thus, the obtained values of growth and developmental parameters of NaCl + nitrobein-treated plants appeared consistently lower than the comparable values obtained for the control salinized plants. The magnitude of decrease appeared to be progressive with the increase in concentration of NaCl applied to soil in combination with nitrobein (Table 1).

As stated by Younis *et al.* (2007), the reduction in growth and yield of many crops by salinity is now well documented, and Greenway (1973) reported that inhibited vegetative growth in highly saline media might be due to reduced cell division, cell enlargement and cell wall expansion. The growth of plants may be reduced under salt stress because of (a) an osmotic stress due to a lowering of the external water potential, or (b) effects of specific ions on metabolic processes ranging from the absorption of nutrients to enzyme activation or inhibition. Thus, ion regulation and osmoregulation are subjects of intensive research into possible mechanisms of salt tolerance (Greenway and Munns, 1980). Lettuce plant performance under different treatments of NaCl was affected both by ionic and osmotic effects (Younis *et al.,* 2007).

Table 1: The effects of increasing concentrations of NaCl either alone or in combination with phosphorein and nitrobein biofertilizers on growth and reproductive parameters; length of root (cm plant $^{-1}$), length of shoot (cm plant $^{-1}$), leaf area (cm^{2} plant^{-1}), fresh mass (g plant $^{-1}$), dry mass (g plant $^{-1}$), water content (g plant^{-1}), number of flowers (flower plant^{-1}) and number of fruits (fruit plant^{-1}), of lettuce plants, at vegetative, flowering and fruiting stages. Mean values listed are significantly different from control at $^{*}P \leq 0.05$.

The interaction between salinity and P nutrition of plants is perhaps as complex as or even more confusing than between salinity and N. The interaction is highly dependent upon the plant species (or cultivar), plant development age (Zhukovskaya, 1973), the composition and level of salinity, and the concentration of P in the substrate. Therefore, depending upon plants selected and conditions of the experiment, different results can be obtained (Zhukovskaya, 1973). The microorganisms involved in P solubilization as well as better scavenging of soluble P can enhance plant growth by increasing the efficiency of biological nitrogen fixation, enhancing the availability of other trace elements and by production of plant growth promoting substances (Egamberdiyeva *et al*., 2004).

In support of the present results, addition of bio-phosphorus fertilizers (phosphorein or mycorrhiza) in one or two dose resulted in significant increases in vegetative growth, plant dry weight as well as in total marketable yield and its components of a variety of crop plants (Sirvastava *et al*., 1998; Ali, 2001; Abdalla, 2002; Hassan *et al*., 2005). Furthermore, Zayed (1998) and Manjunatha *et al.* (1999) stated that inoculation of plants with different biofertilizers including mainly nitrogen fixing and phosphorus solubilizing bacteria and plant growth-promoting microorganisms either singly or in combination with each others, may increase crop production either by making the other nutrients available or by protecting plants from the pathogenic microorganisms.

The promoting effect of phosphorein biofertilizer on growth and development of the variously salinized lettuce plants at vegetative, flowering and fruiting growth stages, may be due to the active bacteria in phosphorein which is capable of transforming the tri-calcium phosphate to mono-calcium phosphate as earlier reported by Ashour (1998). Also as Sherif *et al*. (1997) stated; the phosphates dissolving bacteria presses the ability to bring insoluble phosphate to soluble forms secreting organic acids such as formic, acetic and lactic acids. Such acids lower the pH and bring about the dissolution of bond forms of phosphate and render them available for growing plants.

The response of plants to bio-N-fertilizers was studied by Fisinin *et al*. (1999), Rizk and Shafeek (2000) and Adam (2002) who reported that bio-N-fertilizer has a great number of symbiotic and non symbiotic bacteria which are responsible for nitrogen fixation by atmosphere. Its application appeared to achieve increasing the availability of various nutrients by plants as well as increasing the resistance of plants to root disease and reducing the environmental pollution by chemical fertilizer application. The stimulatory effects of nitrobein biofertilizer might be attributed to the activation of the growth of microflora including production of many plant growth stimulators. The enhancement of the growth attributes led to improving the crop productivity.

The reduction in growth as well as in reproductive parameters of salinized lettuce plants treated with nitrobein and consequently the observed values of negative percent recovery (see table 1) lend a strong support to the findings of El-Saht *et al.* (2000 and 2001). They stated that in certain plants, the reduced form of nitrogen ultimately available for direct assimilation is

NH_4^+ which comes form symbiotic N_2 fixation (nitrobein), urea application or photorespiration. The degree of NH_4^+ assimilation in tissues appears to be a function of organ development, environmental conditions, nutritional status and genotype of species. Since NH_4^+ is generally toxic to plant cells at high concentrations (Vance *et al.,* 1988), this might be the reason that salinized lettuce plants at vegetative, flowering and fruiting stages did not respond positively to the recommended dose of nitrobein biofertilizer. So, the observed decreases in all growth and reproductive parameters, in the present study, appeared to be a function of N^+ pools maintained with the recommended doses of nitrobein biofertilizer (see table 1).

2- Changes in Carbohydrate content.

Perusal of the data presented in table 2 revealed a sharp progressive significant increase in glucose content with an increase in the concentration of NaCl applied; an opposite situation being apparent for sucrose and polysaccharide contents. For total saccharides, on the other hand, their contents appeared, in general, either not to change (at the vegetative and fruiting stages) or to decrease, below the control content (at the flowering stage).

Inclusion of phosphorein into the media of the salinized lettuce plants induced either significant decreases (at the vegetative stage) or significant increases (at the flowering and fruiting stages) in the contents of glucose and sucrose. The polysacchride contents appeared to increase throughout the entire period of the experiment. On the other hand, for the total saccharides, their content appeared either to decrease significantly (at the vegetative stage) or to increase at the latter flowering and fruiting stages (Table 2). The calculated percent improvement in the various saccharide fraction contents of lettuce plants, due to supplemental addition of phosphorein biofertilizer to the salinized lettuce plants, are presented in table 2.

As compared with control salinized lettuce plants, administration of nitrobein to NaCl-treated plants appeared, in general, to induce a decrease in the contents of glucose, sucrose, polysaccharides and consequently in the total saccharides content, throughout the entire period of the experiment (Table 2). The percentage negative recovery in the various saccharide contents of lettuce plants as a result of supplemental addition of nitrobein biofertilizer are presented in table 2.

In accord with the obtained results, Younis *et al.* (2007) observed a significant decrease in soluble and hydrolysable sugars content of *Vicia faba*, wheat and lettuce plants treated with NaCl. Fernandes *et al.* (2004) reported that glucose content decreases with salt stress, sucrose content was almost three times higher in *Lupinus albus* plants treated with 150 mM NaCl and fructose content did not change significantly. The most significant response of lupin plants to excess NaCl is the increase of sucrose content in leaves, which is partially due to increase in sucrose synthase (SS) activity under salinity. Furthermore, Timpa *et al.* (1986) found that the salt-stressed cotton plants showed two to three times greater amounts of carbohydrates (glucose and sucrose) over the values determined for the control samples.

Table 2: The effects of increasing concentrations of NaCl either alone or in combination with phosphorein and nitrobein biofertilizers on carbohydrate content of lettuce plants, at vegetative, flowering and fruiting stages. The mean values listed are given as mg glucose equivalent 100 g^{-1} dry mass and are significantly different from control at $^{*}P \leq 0.05$.

In support of these results, carbohydrate changes are of particular importance because of their direct relationship with such physiological processes as photosynthesis, translocation and respiration. Among the soluble carbohydrates, sucrose and fructans have a potential role in adaptation to these stresses (Kerepesi and Galiba, 2000).

A possible explanation for the increased total saccharides content of salt-treated lettuce plants fortified with phosphorein biofertilizer at flowering and fruiting stages may be due to the fact that phosphorein biofertilizer plays a fundamental role in converting P fixed form to be soluble form more easily used for plant nutrition by plants. Similar results were found by Zayed (1998) who found that soil microorganisms, known as phosphate solubilizing bacteria (PSB), play a fundamental role in converting P fixed form to be available for plant nutrition.

The activities of carbon and nitrogen assimilatory processes are closely related to rates of plant growth and development. The constancy of this association led modelers of physiological responses to explain whole-plant growth and co-ordinate growth between the shoot and root predominantly in terms of carbon and nitrogen interactions (Wann and Raper, 1979). In case of nitrogen stress, two distinct changes in carbon utilization are commonly observed: (a) starch accumulation in leaves (Radin and Eidenbock, 1986) and (b) a large portion of available carbohydrate is translocated from leaves into the root system resulting in a decline in the shoot/root mass ratio (Ingestad, 1979).

3- Changes in photosynthetic parameters.

Careful examination of tables 3 and 4 reveals the following main points:

a- In relation to water control levels, the contents of photosynthetic pigments (Chl a, Chl b, Cars, and total pigments) in lettuce plants treated with increasing concentrations of NaCl, showed a progressive significant decrease with an increase in the concentration of NaCl throughout the three successive growth stages of the plant. The more was the concentration of NaCl used, the more was the decrease in the total content of both chlorophylls (a+b) and this change was associated with a progressive increase in the values of Chl a/b maintained throughout the experimental period.

b- Supplemental addition of phosphorein biofertilizer to the variously salinized lettuce plants, induced significant increases in Chl a, Chl b, cars as well as in the total pigment contents. The magnitude of response was most pronounced with 4 mmhos NaCl + phosphorein. The calculated percentages of positive improvement in the various photosynthetic pigments in response to supplemental addition of phosphorein are presented in table 3.

c- Administration of nitrobein to the salinized media maintaining lettuce plants, throughout the entire period of the experiment, induced additive decreases in Chl a, Chl b, Cars and total pigment contents below those levels detected in the control salinized plants. The magnitude of response was most pronounced with 10 mmhos NaCl + nitrobein. The calculated percent decrease as well as the calculated negative percentages of recovery in the various photosynthetic pigments in response to supplemental addition of nitrobein are given in table 3.

Again, the pattern of changes in PS II activity of the differently treated lettuce plants, at vegetative, flowering and fruiting stages, showed a progressive significant decrease with an increase in concentration of NaCl. On the other hand, PS II activity in the salinized lettuce plants fortified with the optimum dose of phosphorein, appeared to increase significantly with an increase in salinization (Table 4). For nitrobein, the pattern of changes in photosynthetic activities (PS II) of the salinized as well as of salinized + biofertilizer-treated plants, and also in the magnitude of percent change calculated in relation to control levels were essentially comparable to those patterns maintained for the photosynthetic pigments (Table 4).The calculated percentages of recovery maintained in salt-stressed lettuce due to addition of phosphorein and nitrobein are given in tables 3and 4.

In accord with the above mentioned results, salinity as well as many other stress factors are known to cause changes in physiological processes in plants (Younis *et al.,* 2007). Of atmost importance, photosynthesis of many plants decreased drastically as a result of NaCl salinity (Greenway and Munns, 1980). Data relating to the effect of salinity on the primary photochemical reactions under *in vivo* conditions, however, are limited and conflicting (Maslenkova *et al*., 1991). Salinity-caused reduction in net photosynthetic rate has been attributed to reduced stomatal conductance and/or to reduction in capacity of photosynthetic machinery (Seeman and Sharkey, 1986).

Abu-Hussein *et al.* (2002) showed that the microorganisms in phosphorus biofertilizers produce growth promoting substances which increase the plant growth. This increase in plant growth may increase the photosynthetic rates leading to an increase of the assimilation rates. The present results concerning the positive effects of phosphorein application to salinized lettuce plants upon the photosynthetic components (pigment content and PS II activity) appeared to coincide with those positive effects on the dry mass accumulation and yield in lettuce plants. In both cases the values maintained appeared to increase positively and significantly. This gives us a reason to admit that one of the factors providing higher dry mass accumulation and higher yield in treated lettuce plants was the increased capacity for CO_2 assimilation (Jungklang, 2005; Younis *et al.,* 2007).

Since photosystem II (PS II) is believed to play a key role in the response of photosynthesis to environmental perturbations (Baker, 1991), the effects of salinity stress on PS II have been investigated extensively. However, the collected data on the effects of salinity stress on PS II photochemistry are conflicting. Some studies have shown that stress inhibits PS II activity (Everard *et al.,* 1994), whereas other studies have indicated that salt stress has no effect on PS II (Abadia *et al.,* 1999).

The influence of nitrogen on plant growth and development is often connected with the process of photosynthesis because the quantity of nitrogen, in the highest degree, determines the formation and the functional state of assimilation apparatus of plants (Ivanova and Vassilev, 2003).

Table 3: The effects of increasing concentrations of NaCl either alone or in combination with phosphorein and nitrobein biofertilizers on the contents of photosynthetic pigments (mg 100 g^{-1} fresh mass) in lettuce plants, at vegetative, flowering, and fruiting stages. Mean values are significantly different from control at $^{*}P \leq 0.05$.

Table 4: The effects of increasing concentrations of NaCl either alone or in combination with phosphorein and nitrobein biofertilizers on photosynthetic activity (PS II activity), in lettuce plants, at vegetative, flowering, and fruiting stages. The mean values listed are presented as μM DCPIP red. mg^{-1} chl h^{-1} and are significantly different from control at $^{*}P \leq 0.05$.

It is well known that nitrogen nutrition influences the content of photosynthetic pigments, the synthesis of the enzymes takingpart in the carbon reduction and the formation of the membrane system of chloroplasts (Lishtenthaler and Wellburn, 1983).

In the present study, the decreasing tendency of Chl content and Chl fluorescence appeared to coincide with the biomass reduction in salinized lettuce plants fortified with nitrobein throughout the entire period of the experiment (see table 3 and figure 3). The decrease in Chl a+b content was mainly attributed to the distribution of Chl b, which is more sensitive to salinity than Chl a (Jungklang, 2005). In lettuce, Chl a+b appeared to decrease drastically as reported by Singh and Dubey, (1995). This can be attributed to the fact that NaCl stress decreases total Chl content of lettuce plants to increase the activity of Chl degrading chloroplast structure (Younis *et al.,* 2007), inducing the distruction of chloroplast structure and instability of pigment protein complex (Singh and Dubey, 1995). Results obtained from the present study indicate that Chl b is more susceptible to NaCl stress than Chl a and it seems to be a good indicator of salt stress.

In view of the present obtained results, we can suggest that, the biofertilizers can lower the amount of added chemical fertilizer to the saline soil and consequently mitigation of pollution. In addition, the beneficial effects of biofertilizers such as production of organic acids (lowering soil pH) and production of plant growth regulators may contribute to a better plant growth and yield through enhancing nutrient uptake. Also, from the present work phosphorein appeared to give the best beneficial effects on growth and reproductrive parameters of lettuce plants under the four degrees of NaCl (4, 6, 8, 10 mmhos NaCl) especially at the lowest concentration (4 mmhos NaCl), but nitrobein appeared to be not beneficial. Also, we can suggest that, recommended doses of phosphorein biofertilizer, applied as a foliar spray or with irrigation water can be successfully used for ameliorating the adverse effects of NaCl on plant growth (Table 2) and improving the physiological processes of lettuce plants at the three growth stages; nitrobein appeared inefficient in this respect.

Of interest, the data summarized in table 8 show the inhibitory effects of the different levels of salinity used, as well as the optimum percent recoveries maintained for all growth and reproductive parameters determined, in response to application of the recommended dose of either phosphorein and nitrobein biofertilizers, to the variously salinized lettuce plants. Thus, in the light of the presented detailed results as well as Pearson's correlation coefficients made between the changes in the different growth, metabolic and enzymatic parameters, we can conclude that application of phosphorein biofertilizer to NaCl-culture media appeared to be beneficial to growth and development of the salinized lettuce plants, the magnitude of response being most pronounced with 4 mmhos NaCl. On the other hand, application of nitrobein biofertilizer to NaCl-culture media appeared to induce slight, if any beneficial change, to growth and development of salinized lettuce plants, throughout the three successive stages of growth.

Table 5: The percentage inhibitory effects of increasing concentrations of NaCl and the optimum percentage recovery (improvement) induced by application of biofertilizers, for the various growth and reproductive parameters at the three growth stages.

Treatments		parameters	Length of root	Length of shoot	Leaf area	Fresh mass	Dry mass	Water content	Number of flowers	Number of fruits
Inhibition	4 mmhos NaCl	vegetative	-3.8	-13.3	-5.7	-4.2	-4.2	-4.2	-	-
		flowering	-6.3	-15.0	-4.3	-9.8	-13.3	-8.6	-5.3	-
		fruiting	-6.3	-11.9	-	-12.1	-7.7	-13.6	-	-10.5
	6 mmhos NaCl	vegetative	-23.1	-36.7	-11.6	-16.2	-12.5	-16.9	-	-
		flowering	-23.8	-42.5	-9.2	-26.6	-28.9	-25.9	-36.8	-
		fruiting	-21.9	-31.0	-	-21.6	-28.8	-19.0	-	-36.8
	8 mmhos NaCl	vegetative	-23.1	-50.0	-15.9	-32.4	-29.2	-33.1	-	-
		flowering	-27.0	-42.5	-11.6	-35.9	-37.8	-35.3	-47.4	
		fruiting	-28.1	-40.5	-	-30.2	-50.0	-23.1	-	-52.6
	10 mmhos NaCl	vegetative	-40.4	-56.7	-29.1	-65.5	-66.3	-65.3	-	-
		flowering	-36.5	-52.5	-25.2	-64.7	-62.2	-65.5	-100.0	-
		fruiting	-37.5	-50.0	-	-55.3	-63.5	-52.4	-	-100.0
Recovery	4 mmhos NaCl+ phosphorein	vegetative	28.8	66.6	28.1	45.7	95.9	35.6	-	-
		flowering	23.8	65.0	26.3	142.9	148.9	140.9	26.4	-
		fruiting	31.3	98.3	-	137.7	126.9	141.4	-	31.6
	4 mmhos NaCl+ nitrobein	vegetative	-17.4	-26.7	-11.0	-14.1	-12.5	-14.4	-	-
		flowering	-14.3	-10.0	-11.2	-19.5	-20.0	-19.5	-15.8	-
		fruiting	-14.0	-14.3	-	-8.5	-26.9	-2.0	-	-10.6

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دراسات على نمو وأيض نبات الخس تحت تأثير الملوحة و الخصبات الحيوية

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فى هذا البحث أجريت تجربتان بمركز البحوث الزراعية (وحدة خصوبة التربة) بالمنصورة- حيث تم فيها زراعة شتلات نبات الخس فى خليط من تربة طينية : طفلية بنسبة حجمية ١:٢ إماخالية (كعينات ضابطة) أو مضافاً إليها أى من ٤ مستويات من ملح كلوريد الصوديوم (٤،٦، ٨، ١٠ ملليموز) ولقد تم معاملة نباتات الخس المجهدة بملح كلوريد الصوديوم بمخصبان حيويان هما:- الفوسفورين و النيتروبين. ولقد صممت هاتان التجربتان بهدف دراسة نمو و أيض نبات الخس تحت تأثير الملوحة و المخصبات الحيوية فى مراحل النمو الخضرى و الزهرى و الثمرى .لوحظ أن إضافة الكمية الموصى بها من المخصب الحيوى الفوسفورين إلى التربة الملحية حفزت الزيادة المعنوية فى جميع دلالات النمو و الإنتاج لنباتات الخس خلال فترة التجربة. من ناحية أخرى تخصيب التربة الملحية بالكمية الموصى بها من المخصب الحيوى النيتروبين أظهرت نقص بسيط فى جميع دلالات النمو و الإنتاج خلال مراحل النمو الخضرى والزهرى والثمرى.و بالنسبة للمحتوى الكلى للمواد الكربوهيدراتية بالإضافة إلى المحتوى الكلى للأصباغ وكفاءة المسار الضوئى ٢ لنباتات الخس المزروعة فى التربة الملحية والمخصبة بالفوسفورين أظهرت زيادة خلال مراحل النمو الثلاثة عن العينات الضابطة. من ناحية أخرى المعاملة بالنيتروبين أحدث تغيرات طفيفة فى جميع عمليات الأيض المقدرة خلال فترة التجربة.علاقات إجابية و سلبية لوحظت بين التغيرات فى دلالات النمو و الإنتاج و التغيرات فى عمليات الأيض المقدرة لنباتات الخس فى البيئة الملحية المخصبة بالفوسفورين والنيتروبين على التوالى.