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Influence of Salinity of Water for Irrigation on NPK Nutrients Uptake in Greenhouse Traditional Cultivation of Cauliflower (*Brassica oleracea var. botrytis* L.)

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Abstract

The NPK nutrients uptake in the production of cauliflower (*Brassica oleracea var. botrytis* L.) irrigated with different water quality (fresh and saline water of 4 dS/m) has been analyzed in the experiment conducted in the greenhouse of Mediterranean Agronomic Institute of Bari. The highest nitrogen (N) consumption was observed 10 weeks after transplantation, while the highest consumption of phosphorus (P) and potassium (K) was recorded 12 and 8 weeks after transplantation, respectively. The highest concentration of N in vegetative part was obtained in cauliflower under saline water irrigation (3.5%), while in the fresh water treatment concentration of N was 3.2%. The phosphorus uptake was significantly affected under saline irrigation practice with respect to the fresh water being with total P uptake value corresponding to about 61% of the its uptake under the fresh water treatment. Irrigation with the salinity level of 4 dS/m resulted in significant increase in the accumulated salts in soil being with an electric conductivity (EC) value 17% greater than the one where fresh water was practiced. Evolution of chloride (Cl^-) and its average values during the whole cropping period indicate that Cl^- behaved in a manner identical to the one characterizing the EC parameter. This proves that Cl^- concentration in the soil can be taken as a measure expressing the soil salinity.

Key words: nutrients, cauliflower, nitrogen, saline water, EC

Introduction

Irrigation water quality has a profound impact on crop production. Irrigation water contains dissolved mineral salts, but concentration and composition of salts depended highly on the source the irrigation water.

One of the most important factors for a successful vegetable production is water quality and availability. The choice must be based mainly on quality, storage capacity and price (Van Assche & Vangheel, 1989). Accurate knowledge of crop water requirement is a pre-requisite for an efficient and safe management of water and fertilizers. The amount of both water and nutrients to be delivered will differ according to the variation of the crop, its growth stage, the water quality, the climatic conditions in the cropping environment including the absence and or in the presence of heating systems and the cropping season. Since the copping media under traditional cultivation technique is soil, it could be expected chemical changes as well as precipitation of the applied nutrients.

In the traditional cultivation technique, salinity depending on the nature and the amount of soluble salts, exerts a variety of effects on the plant concerning its development, the yield and quality of the output, the crop variety as well as the salinity tolerance of the plant different development stages; not to forget the atmospheric conditions they effect the rate of evapotranspiration and the irrigation management. The effect of saline irrigation water application on the plant development acts through two ways; it either has a direct impact on the plant status or it indirectly alters the plant functioning through breaking the soil natural equilibrium modifying thus its conducting properties for the plant survival (Hamdy, 2002). In general, soil salinity, either caused by saline irrigation water or by a combination of water, soil and crop management factors, may result in: reduction in size of the produce; change in colour and appearance; and change in the composition of the produce. Rhoades et al. (1989) obtained increases in the quality of wheat, melons and alfalfa from use of saline drainage water for irrigation (FAO, 1992). Cauliflower is classified as moderately sensitive to salinity. Increasing irrigation frequency and applying water in excess of plant demand may be required during hot, dry periods to minimize salinity stress (Tanji, 1990).

The recommended range of irrigation water pH for production depends on the crop being grown. In general, pH should range from 5.2 to 6.8. If the pH and alkalinity are high, the water may need acid treatment prior to use on crops. Water pH levels above the desirable range hinder absorption of certain nutrients, which may cause toxicity (Jensen & Malter, 1995). Starving the plants from nitrogen can prevent curd initiation (Atherton et al. 1987). This is because the leaf area development is restricted and the plant cannot support generative growth. In plants growing in nitrogen deficient conditions physiological disorders like "buttons" can occur (Carew & Thompson, 1948). Potassium deficiency can also occur, causing shortening of internodes, thickening and curling of lamina, purple pigmentation along the leaf veins, inhibition of curd formation and floral bud necrosis (IFA, 1992).

The use of saline water has depressive effects on many crops and therefore it can be a major problem in those areas of the Mediterranean region where vegetables are extensively grown and shortage of good quality water is very common. (Incalcaterra et al., 2003).

Materials and methods

It was grown Cauliflower variety Fremont (Hybrid) Royal Sluis (*Brassica oleracea*), showing excellent weight, uniformity, density and color. Cauliflower was grown under traditional technique using water of diffetrent salinity (fresh and saline water of 4 dS/m). The experimental surface was of an area about 80 m^2, with 40 m^2 for each irrigation treatment. Each irrigation treatment included 8 replicates. The distance between plants was 50 cm and 80 cm between the lines, which gives a plantation density of 2.5 seedlings/m^2. The experimental layout is given in Fig. 1. Cauliflower seedlings were transplanted on 01.12.2004. Harvest was done on 22.03.2005, when it achieved full maturity.

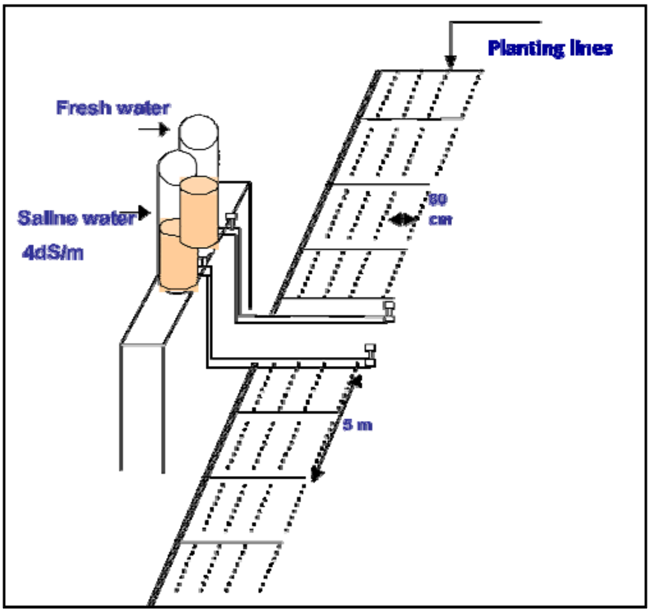

Fig. 1. Traditional technique experiment layout
Šema tradicionalne tehnike eksperimenta

Before fertigation soil physical and chemical analysis had been done as well as chemical analysis of fresh and saline water for irrigation. Irrigation scheduling was established taking into consideration the daily observation of evaporation from the "Class A" pan installed in the greenhouse. The fresh water and prepared saline water were contained in separate tanks of a volume of 200 l. Both tanks were connected to the irrigation network for water delivery. drip irrigation system was used with drippers discharge of 4 $l \cdot h^{-1}$. The first two weeks after plantation irrigation was practiced with fresh water (1.1 dS/m). After that, in the fresh water treatment fertigation continued with fresh water till harvesting, where as for saline one, fertigation was practiced with the saline water (4 dS/m). The irrigation scheduling for cauliflower is given in Tab. 1.

Tab. 1. Cauliflower irrigation schedule
Raspored navodnjavanja karfiola

Irrigation scheduling *Raspored navodnjavanja*	
Irrigation frequency *Učestalost navodnjavanja*	Irrigation water quantity (mm) *Količina vode za navodnjavanje (mm)*
	4
After 18 days *Nakon 18 dana*	4
After 12 days *Nakon 12 dana*	6
After 12 day *Nakon 12 dana*	8
After 12 days *Nakon 12 dana*	8
After 12 days *Nakon 12 dana*	8
After 8 days *Nakon 8 dana*	10
After 10 days *Nakon 10 dana*	10
After 9 days *Nakon 9 dana*	10
After 8 days *Nakon 8 dana*	12
After 10 days *Nakon 10 dana*	12

For calculation of irrigation water quantity it was taken into consideration 20% of leaching and 95% of efficiency of irrigation system.
The fertilizer requirements of cauliflower are 200 kg/ha N, 75 kg/ha P and 225 kg/ha K (Dellacecca, 1990). The compositions of the macronutrient and micronutrients solution practiced during the running of the experiment of cauliflower are given in (Tab. 2.). Two applications of nutrients has been done in vegetative development stage while in initiation of flowering and fruit development stage one application of fertilizers has been done.

Tab. 2. Macro and mickro nutrients for each application
Makro i mikro hraniva za svaku primjenu

Fertilizers *Đubriva*	Cauliflower *Karfiol*
Calcium nitrate (15.5% N, 20 Ca)	680 g
Potassium nitrate (14% N, 46% K_2O)	660 g
Potassium phosphate 35 K_2O, 53% P_2O_5)	330 g
Iron chelates (4.5% Fe)	70 g
Micronutrients	100 g

Every 20 days values of pH and EC, as well as concentration of Cl and Na in saturated soil paste were analyzed. Every 15 days NPK nutrients were analyzed in vegetative and radical organs of plants. The total nitrogen was analyzed by an automatic distillation apparatus "Distillation links, UDK 140" using Kjeldhal method. Phosphorus was determined bu Olsen method (method blue of molybdenum), while potassium was determined by photometry using flame photometer (JENWAY PEP 7). For statistical analysis one way ANOVA and Duncan test has been used.

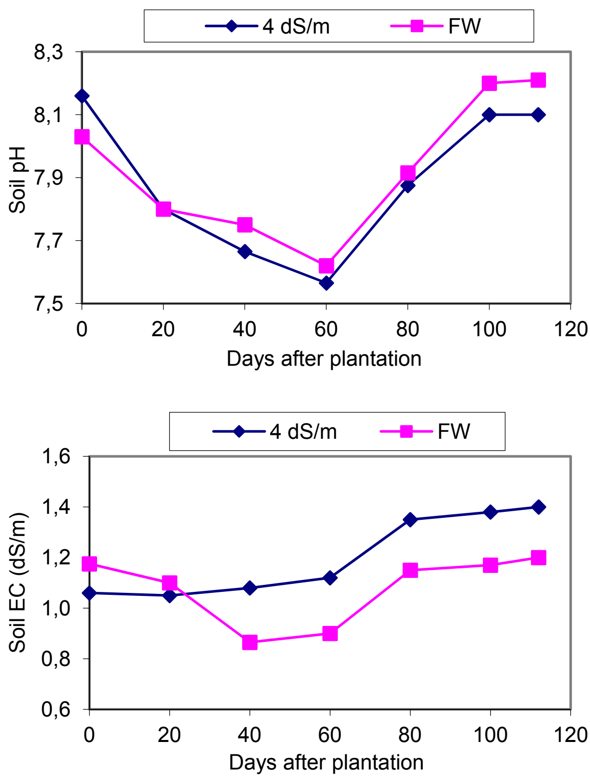

Fig. 2. Dynamics of soil pH during the growing period
Dinamika pH zemljišta tokom perioda vegetacije

Results and discussion

Evolution of soil pH and EC during the growing period of cauliflower in both treatments are shown in Fig. 2.

The data indicate that under the saline irrigation practice the pH were of values very similar to the ones where fresh water was practiced showing under fresh water values slightly higher with the respect to the ones measured under the 4 dS/m irrigation treatment. Taking the overall pH average during the cropping cycle, it is quite clear that increasing the salinity of irrigation water from 1.1 dS/m to 4 dS/m did not result in any significant variation in the soil pH.

The presented data indicate that under saline irrigation practices with successive irrigations there was a gradual increase in the accumulated salts in the soil. However, the end of the cropping cycle, the accumulated salts were of an EC value around 1.4 dS/m, which most of the crops could tolerate, but in comparison with the fresh water treatment it is significant increase (17%) in the accumulated salts in soil.

In the Fig. 3 is presented evolution of Cl^- and Na^+ concentration in soil paste in both treatments.

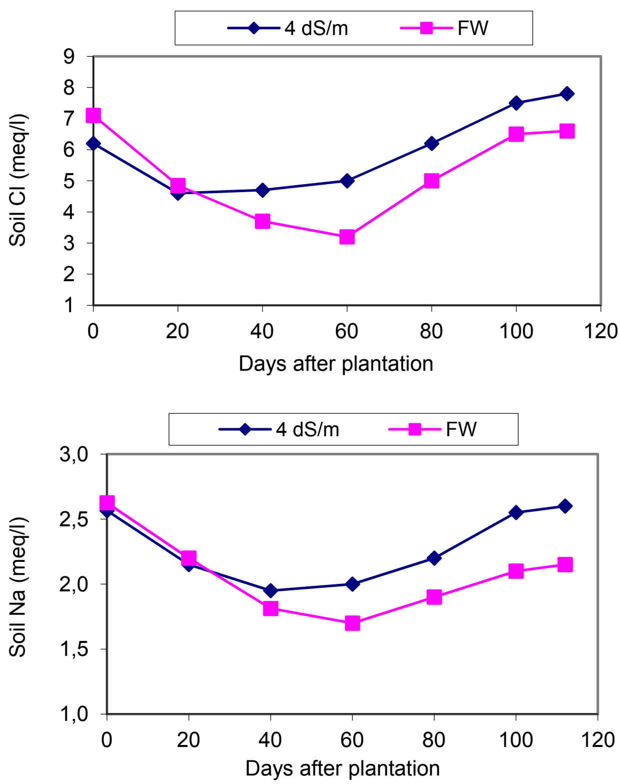

Fig. 3. Dynamics of soil pH during the growing period
Dinamika pH zemljišta tokom perioda vegetacije

Chloride evolution data indicate that Cl^- behaved in a manner identical to the one characterizing the EC parameter, showing at the end of cropping cyccle about 18% higher Cl concentration in saline water treatment. This proves that Cl^- concentration in the soil can be taken as a measure expressing the soil salinity. Regarding Na concentration in the soil at the end of growing period there was no significant difference between treatments.

In this paper evaluation of the NPK nutrients status during the copping cycle of cauliflower grown under traditional technique under two irrigation treatments is analyzed. in The nitrogen (N) concentration in both vegetative and radical part during the cropping cycle is presented in Fig. 4.

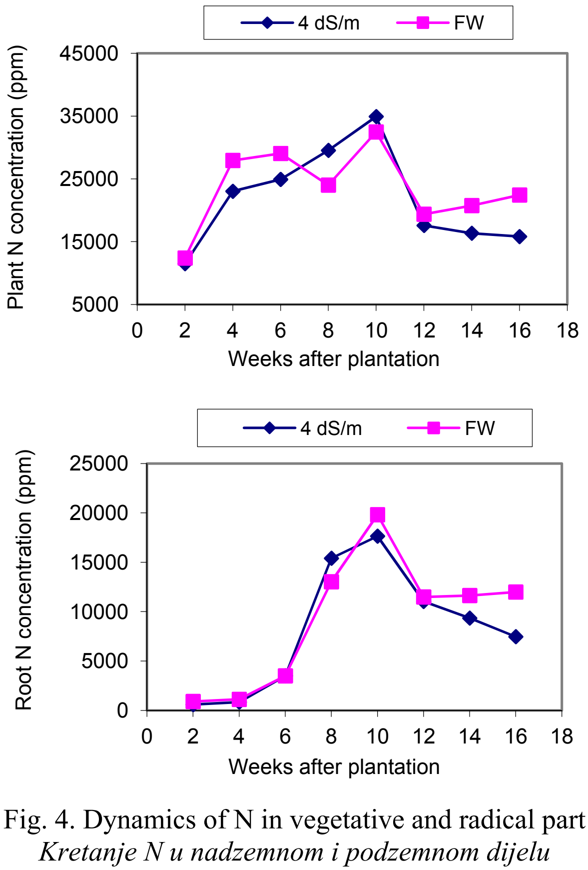

Fig. 4. Dynamics of N in vegetative and radical part
Kretanje N u nadzemnom i podzemnom dijelu

Regarding the N concentration, it is quite clear that during the cropping cycle, both vegetative and radical part followed more or less the same trend between treatments. There was a gradual increment in the nitrogen concentration reaching its maximum concentration after 10 weeks from transplanting, the time where vegetative growth is completed and the start the inflorescence head formation, then it sharply declined being more or less with the same concentration till harvest time. The data also show that irrigation with saline water of 4dS/m resulted in a slight differences in the N concentration being in values slightly lower than in the ones where irrigation was done with fresh water. The highest concentration of N in vegetative part was obtained in cauliflower under saline water irrigation (3.5%), while in the fresh water treatment concentration of N was 3.2%. Regarding the N concentration in the roots during the cropping cycle, it is clear that it followed a trend different from one concerning the vegetative part. The highest concentration of N in roots were in treatment with fresh water (2.0%), while in saline water treatment was obtained 1.8%. The presence of the N in the roots with concentration nearly 50% lower than the vegetative part with the whole cropping cycle indicate high mobility of the nitrogen and its transport to the vegetative growth with little accumulation in the roots.

The total N uptake by plants was the highest in the treatment with fresh water (6790 mg·plant^{-1}) which is significantly 70% higher than the one corresponding to saline water treatment (3783 mg·plant^{-1}) (Tab. 3.)

Tab. 3. Nitrogen uptake (mg·plant^{-1}) by plant during growing period
Usvajanje azota (mg·biljka^{-1}) po biljci tokom perioda vegetacije

Water salinity *Slanost vode*	FW	4 dS/m
Vegetative part *Nadzemni dio*	6347	3574
Radical part *Podzemni dio*	443	209
Total *Ukupno*	6790 **	3783

** – significant difference on 0.01 P level
značajna razlika na 0.01 P nivou

The phosphorus (P) concentration in both vegetative and radical part during the cropping cycle is presented in (Fig. 5).

Evolution of P in both the vegetative and radical parts, followed a trend more or less similar to the one characterizing the nitrogen evolution with the only difference is that maximum P concentration was found to be after 12 weeks from transplanting, the time of the formation of the fruits. This indicates that the phosphorus requirements of the cauliflower varies with the variation of growth stage, it is relatively higher at the formation of inflorescence head rather than during the development of the vegetative growth. The same P concentration in vegetative part was obtained in both treatments showing value of 0.88%, while in the roots there was a slightly (13%) higher concentration under saline water irrigation (0,43%) in comparin with fresh water treatment.

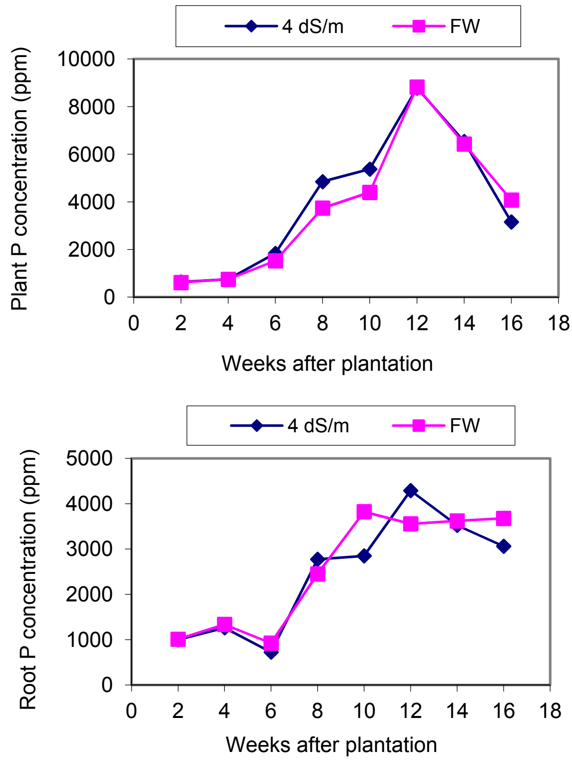

Fig. 5. Dynamics of P in vegetative and radical part
Kretanja P u nadzemnom i podzemnom dijelu

Like the nitrogen, also the phosphorus uptake was significantly affected under saline irrigation practice with respect to the fresh water treatment being with total P uptake value corresponding to about 61% of the its uptake under the fresh water treatment (Tab. 4).

Tab. 4. Phosphorus uptake ($mg \cdot plant^{-1}$) by plant during growing period
Usvajanje fosfora ($mg \cdot biljka^{-1}$) po biljci tokom perioda vegetacije

Water salinity *Slanost vode*	FW	4 dS/m
Vegetative part *Nadzemni*	1153	714
Radical part *Podzemni dio*	136	86
Total *Ukupno*	1289 **	800

** – significant difference on 0.01 P level
značajna razlika na 0.01 P nivou

The potassium (K) concentration in both vegetative and radical part during the cropping cycle is presented in (Fig. 6).

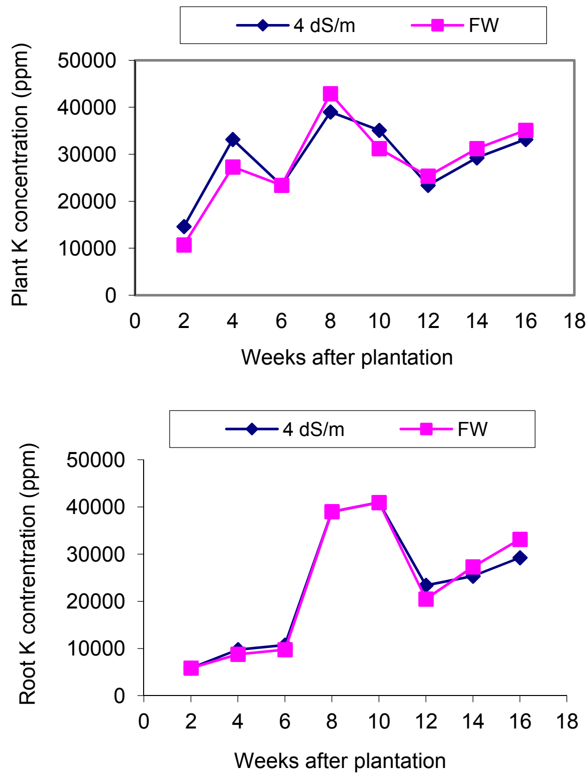

Fig. 6. Dynamics of K in vegetative and radical part
Kretanje K u nadzemnom i podzemnom dijelu

The third element potassium, its concentration in the vegetative part followed a trend different from the one characterizing its status in the roots during the cropping cycle particularly at the earlier growth stages. However, in both vegetative and root parts potassium was found at its highest concentration when the development in both parts was nearly completed (8 weeks from transplanting), then it sharply dropped after 12 weeks of plantation, then it again gradually increased till the harvest time. Such fluctuation in the K concentration during the cropping cycle in the vegetative part as well as the radical one could be attributed to rate of development of both with the progress of cropping period.

Irrigation with the 4 dS/m water resulted in very slight variation in the K concentration with respect to the fresh water. In the Tab. 6. is presented K exportation by plant during the growing period.

Tab.5. Potassium uptake (mg·plant^{-1}) by plant during growing period
Usvajanje kalijuma (mg·biljka^{-1}) po biljci tokom perioda vegetacije

Water salinity *Slanost vode*	FW	4 dS/m
Vegetative part *nadzemni dio*	9933	7492
Radical part *podzemni dio*	1227	819
Total *ukupno*	11160	8311

Similar to N and P uptake, the K uptake by the vegetative part of cauliflower irrigated with fresh is 33% higher then in vegetative part under saline irrigation water practice. In total, K uptake under fresh water treatment is 34% greater then in treatment with saline water.

Conclusion

The highest consumption of NPK nutrients was recorded in 10, 12 and 8 weeks after transplantation, respectively. Obtained results shows that cauliflower is moderately sensitive crop to increased salinity of irrigation water, what led to slighly lower consumptions of nutrients in regard to fresh water irrigation treatment. Taking into account that water is a scarce natural resource, especially in the Mediterranean countries, saline water could be an alternative to fresh water up to the range that is acceptable according to the plant sensitivity to irrigation water salinity.

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Uticaj saliniteta vode za navodnjavanje na usvajanje NPK hraniva u stakleničkoj proizvodnji karfiola (*Brassica oleracea var. botrytis* L.) na tradicionalan način

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Sažetak

U eksperimentu koji je sproveden u stakleniku Mediteranskog agronomskog instituta u Bariju analizirano je usvajanje NPK hraniva u proizvodnji karfiola navodnjavanog vodom različitog saliniteta (svježa voda i voda saliniteta od 4 dS/m). Najveća potrošnja azota je zabilježena 10 sedmica nakon presađivanja, dok je najveća potrošnja P i K zabilježena 12, odnosno 8 sedmica nakon presađivanja. Najveća koncentracija N u nadzemnom dijelu karfiola je dobijena u tretmanu sa slanom vodom (3.5%), dok je u tretmanu sa svježom vodom koncentracija N bila 3.2%. Usvajanje fosfora je značajno smanjeno u tretmanu sa slanom vodom u odnosu na tretman sa svježom vodom, pokazujući sadržaj ukupno usvojenog P za 61% manji u odnosu na tretman sa svežom vodom. Navodnjavanje sa vodom saliniteta 4 dS/m je rezultiralo u značajnom povećanju akumuliranih soli u zemljištu, pri čemu je vrijednost električnog konduktiviteta (EC) bila 17% veća u odnosu na tretman sa svježom vodom. Kretanje sadržaja hlora (Cl^-), kao i njegova srednja vrijednost za cijeli vegetacioni period, pokazuje istu tendenciju kao i električni konduktivitet, što ukazuje na to da vrijednost sadržaja Cl^- u zemljištu može da bude jedan od parametara za ocjenjivanje saliniteta zemljišta.

Ključne riječi: hraniva, karfiol, nitrogen, slana voda, EC

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