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Influence of agricultural effluent irrigation on common purslane (*Portulaca oleracea* L.) and garden basil (*Ocimum basilicum* L.): preliminary results

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Abstract: The agricultural costs can be reduced with waste water application. The effect of water quality was tested on several parameters of purslane and basil. Four treatments were applied (Irr0: non-irrigated control; Irr1: effluent water from an intensive African catfish farm; Irr2: diluted effluent water with gypsum; Irr3: Körös-oxbow lake water as irrigated control). Completely random sampling was used, ten plants were measured per treatment. The purslane developed the most shoots by Irr0 (8.70 number plant^{-1}); and the treatment of Irr3 decreased it significantly (4.80 number plant^{-1}). Regarding the fresh root weight, significant difference was found between the Irr0's maximum value (7.83 g plant^{-1}) and the Irr3's minimum one (3.87 g plant^{-1}). For biomass Irr0 treatment resulted in the maximum yield (413 g plant^{-1}); there were not significant differences among the treatments. Very strong positive correlation was noted between the fresh root weight and the biomass ($p = 0.01$; Pearson's $r = 0.84$). Based on our result purslane does not require high amount of water. For basil the benefical effects of Irr3 irrigation were detected; there were significant differences among the treatments. The highest values of the parameters were in Irr3: plant height (47.96 cm), root length (23.22 cm), biomass (164 g plant^{-1}, fresh floral shoot tip (85.56 g plant^{-1}), fresh stem (78.44 g plant^{-1}) and fresh root weight (9.38 g plant^{-1}). At basil very strong positive correlation was evinced between the biomass, and fresh root weight ($p = 0.01$; Pearson's $r = 0.87$). The significantly more yield was achieved by irrigation on basil. Irrigation with undiluted effluent water (Irr1: biomass: 124.50 g/plant) is similarly effective to increase yield, as in Irr3.

Keywords: herbs, irrigation, salinity, yield, waste water

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Introduction

Around the world the raw matter production as cost-effectivly as possible is the one of the most important factors during the growing season of herbs. Due to climate change weather extremities are more frequent nowadays, the precipitation does not fall in the right time and it occurs in unpredictable amount; as a result the irrigation contributes to an increasingly bigger part of the production costs nowadays.

In the future, the solution can be preferably herbs such as purslane (*Portulaca oleracea* L.) that do not require irrigation or irrigation with effluent water from agricultural sector can be applied in case of plants with high water requirement such as basil (*Ocimum basilicum* L.).

Portulaca oleracea L. is a herbaceous succulent annual plant with a cosmopolitan distribution belongs to the Portulacaceae family, is commonly known as purslane in English. It is consumed extensively as a potherb in many Mediterranean and tropical Asian countries and added in soups, salads and has been used as folk medicine. Diverse compounds have been isolated from *Portulaca oleracea*, such as flavonoids, alkaloids, polysaccharides, fatty acids, terpenoids, sterols, proteins vitamins and minerals. *Portulaca oleracea* possesses a wide spectrum of pharmacological properties such as neuroprotective, antimicrobial, antidiabetic, antioxidant, anti-inflammatory, antiulcerogenic, and anticancer activities (Zhou et al., 2015). The purslane is an alternative source of omega-3 fatty acids (Petropoulos et al., 2015).

Basil wellknown as sweet or garden basil, a member of the Lamiaceae family, is cultivated throughout the Mediterranean region (Abbas, 2010). Its fresh, dried leaves and floral shoot tip are used as carminative, galactogogue, stomachic and antispasmodic medicinal plant in traditional medicine (Sajjadi 2006). The potential uses of *O. basilicum* essential oil has been investigated, especially as antimicrobial and antioxidant. The chemical composition of basil essential oil has been studied in several studies. The main effective compounds of *O. basilicum* are methyl chavicol, linalool, methyl cinnamate, methyleugenol, eugenol and geraniol (Sajjadi, 2006). One of the most important positive effects of using wastewater is the reduction in agricultural cost. This type of water is usable throughout the year and has no access restrictions (Jiménez, 2006; Khater et al., 2015).

The use of fish farm effluent in plant production has been reported for the cultivation of several species, such as tomato (Castro et al., 2006; Jchappell et al., 2008; Khater et al., 2015), basil, marigold (Hundley et al., 2013), lettuce (da Rocha et al., 2017), legumes (Silva et al., 2018), potato, soybean, onion (Abdelraouf, 2019), rice (Ibadzade et al., 2020), and willow (Kolozsvári et al., 2021). The combination of fish farming and agriculture can reduce the need for irrigation (McMurtry et al., 1997). The use of saline water for irrigation on various crops, such as quinola and ocra, has already been implemented (Azeem et al., 2020; del Carmen Rodríguez-Hernández et al., 2021).

In some cases, the effluent waters from fish farming can contain high saline level due to its origin (Kolozsvári et al., 2021). Significant salt tolerance had been already published on *Melissa officinalis*, *Echinacea purpurea*, *Thymus vulgaris* and *Matricaria chamomilla* (Bistgani et al., 2019; Omer et al., 2014; Ozturk et al., 2004; Sabra et al., 2012). Utilization of wastewater and compost increased the basil yield and nutrient content (Marofi et al., 2015). Alam et al. (2015) investigated the effect of salinity (0, 8, 16, 24 and 32 $d\mathrm{Sm}^{-1}$) on 13 purslane genotypes: salinity stress caused significant reduction in all measured parameters (biomass production, physiological parameters, and stem-root anatomical changes) and the highest salinity level showed more detrimental effects compared to the control.

According to Kafi and Rahimi (2011) salinity caused a reduction in purslane root and shoot growth (volume, area, diameter, total and main length and root dry weight). According to He et al. (2021) plants grown with 100 mM NaCl had the highest productivity and the fastest leaf growth followed by those with 0, 200 and 300 mM NaCl. Purslane grown with 300 mM NaCl had the lowest specific leaf area, highest leaf dry matter content and the lowest water content.

The purslane can cumulatively remove considerable amounts of salt from the soil in practice to cultivate as an intercrop in orchards. In this regard, 6.5 $d\mathrm{Sm}^{-1}$ can be concluded as the threshold salinity level for the purslane managed to be intercropped (Kiliç et al., 2008). In the short vegetation period of *Portulaca oleracea* can be grown high fresh weight yields of about 70 t ha^{-1} (Kiliç et al., 2008). As for results of Bekmirzaev et

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al. (2021), *P. oleracea* is resistant to salinity, is able to remove sodium ions (400–500 kg ha^{-1} NaCl), and can be grown in saline soil. Inhibitory effects of salinity on biomass production of the shoot and the root, and area of individual leaves were apparent already under cultivation with 25 mM NaCl. Elevation of salinity from 1 to 100 mM NaCl induced 63% and 61% reductions in fresh and dry herb biomass production, respectively (Bernstein et al., 2010). The results reveal that salinity caused significant decreases in growth of basil (Heidari, 2012). Significant decreases in yields were resulted in by increasing salinity levels from 0.4 to 8.0 dSm^{-1}. However, basil could able to survive at high salt stress (Caliskan et al., 2017). The increase in salinity was detrimental to all evaluated variables in both cultivars, but the cultivar 'Roxo' was more tolerant than the cultivar 'Verde'. Both cultivars are tolerant to irrigation water salinity of up to 1.5 dSm^{-1} (Maia et al., 2017). The salt tolerance decreased in the respective order of basil $\approx$ sage > thyme > oregano (Tanaka et al., 2018).

Omeir et al. (2019) published that irrigation with effluent water of fish farm significantly increased the fresh and dry weight of shoot and root, leaf number, and stem height both in purslane and basil, too. In the fish farm treatment, the fresh weight of shoots increased 203% and 250% compared to river water irrigation, in basil and purslane, respectively. The using of effluent water of fish farm in irrigation may satisfy water requirement.

Our aim was to prove the suitability of the effluent water irrigation to grow common purslane and garden basil.

Materials and Methods

The experiment was carried out at the MATE IES ÖVKI Lysimeter Station in Szarvas, Hungary in 2021. The soil of the experimental field was charaterized by low humus content, slightly alkaline, clay loam (Filep, 1999). Nitrogen supply is poor, phosphorus supply is excessive and the potassium content of the soil is high (Hoppe, 2009; Kádár, 1992; MéM NAK, 1979) (Table 1.).

The season was drier and warmer than the 30-year average (1981–2010). June was very dry, because only 1.2 mm was the natural precipitation. The irrigation was carried out seven times from May to August. Overall, the total amount of irrigation was 105 mm (Table 2.).

Effect of water quality was tested on several parameters of purslane and basil. Four treatments were applied. (Irr0: non-irrigated control; Irr1: Effluent water from an intensive African catfish farm; Irr2: Diluted effluent water with gypsum: 1/3 effluent water+2/3 Körös-oxbow water+ 0,312 kg m^{-3} gypsum; Irr3: Körös-oxbow lake water as irrigated control). The effluent water has higher macro nutrient content than water of Körös oxbow. The Na- content of Irr1 was ten times higher than to Irr3 (Table 3.).

Completely random sampling was used, ten plants were measured per treatment. In case of purslane four plant properties - plant diameter (cm), number of offshoots (number $plant^{-1}$), shoot length (cm), root length (cm)- and two yield parameters - fresh root weight (g $plant^{-1}$) and biomass weight (g $plant^{-1}$) - were studied. On basil five plant properties - plant height (cm), plant diameter (cm), number of offshoots (number $plant^{-1}$), root length (cm), and SPAD value - and six characterising features of yield - weight of biomass, floral shoot tip, dry herba, fresh stem, fresh root, dry root (g $plant^{-1}$) - were examined.

SPAD values were measured with Konica Minolta SPAD-502 chlorophyll meter from an average of 6 replicates per stem. The SPAD value was determined on the third mature leaf pair under the floral part. The weight of fresh biomass, fresh floral shoot

Table 1: Characteristics of the soil of experimental field (Szarvas, 2021)

Soil depth	pH (KCl)	Soil texture	Total carbonate content (% w w^{-1})	Humus (% w w^{-1})	Nitrite + Nitrate-N (KCl) (mg kg^{-1})	P_2O_5 (AL) (mg kg^{-1})	K_2O (AL) (mg kg^{-1})	Na (AL) (mg kg^{-1})
0-30 (cm)	7.21	clay loam	1.14	2.20	3.64	2230.00	609.00	77.60

Table 2: The comparison of monthly precipitation and temperature data between the study period and reference period (1981-2021)

Season	Precipitation (mm) 2021	Precipitation (mm) 1981-2010	Average Temperature (°C) 2021	Average Temperature (°C) 1981-2010	Irrigation (mm) 2021)
January	48.90	29.10	1.76	-1.04	0.00
February	33.90	29.93	3.10	0.54	0.00
March	10.30	27.83	5.98	5.59	0.00
April	62.50	42.03	9.08	11.47	0.00
May	65.10	50.57	14.75	16.80	15.00
June	1.20	61.27	22.74	19.84	75.00
July	48.30	57.53	25.15	21.91	15.00
Sum or Average	270.20	298.26	11.79	10.73	105.00
Season of May–July	114.60	169.37	20.90	19.50	105.00

tip, fresh stem parts were measured with CAS 25 type scales and the fresh root, the dry root and dried herba of basil weight were measured with CAS MWP-1500. The leaves, floral shoot tips and roots were dried in the ÖVKI Laboratory for Environmental Analytics in Szarvas in a Memmert UFP 800 oven at 40 °C.

Basil seedling was planted on May 17, 2021. In 40 cm row space and 15 cm planting distance. Harvest was done on July 8, 2021.On purslane plant number setting was done on June 8, 2021 from natural weed flora of the Lysimeter Station in 40 cm row space and 40 cm planting distance. Harvesting was in July 16, 2021.

To the evaluation of the results MS Excel 2012 and IBM SPSS 22 softwares were used. The outliers were excluded from further analysis. The variances ($p = 0.05$) of parameters in the four irrigation treatments were compared with one-way analysis of variance (ANOVA). Tukey test was applied at Post Hoc test. The relationships were determined between the plant properties by Pearson's correlation ($p = 0.01$).

Results

Results of purslane

Regarding the plant diameter there were not significant differences among the treatments; the highest diameter was detected in the diluted effluent water plus gypsum treatment (Irr2) (75.1 ± 11.06 cm). Significant differences were found only in case of the number of offshoots between Irr0 (8.7 number

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Table 3: Characteristics of effluent water from intensive fish farming (Irr1) and Körös oxbow water (Irr3) (Szarvas, 2021)

Characterstics of irrigation water	Effluent water	Körös oxbow water
Temperature of water (in laboratory)* (°C)	20.00	16.60
pH (in laboratory)	7.88	7.67
Specific electric conductivity (20 °C) (μS/cm)	1380.00	329.00
Total alkalinity (p-alkalinity) (mmol l^{-1})	<0.10	<0.10
Total alkalinity (m-alkalinity) (mmol l^{-1})	16.70	2.79
Carbonate (mg l^{-1})	<6.00	<6.00
Bicarbonate (mg l^{-1})	1 016.00	170.00
Ammonium ion (mg l^{-1})	36.10	0.45
Ammonium-N (mg l^{-1})	28.00	0.35
Nitrite ion (mg l^{-1})	0.26	0.10
Nitrite-N (mg l^{-1})	0.08	0.03
Nitrate ion (mg l^{-1})	<0.44	2.80
Nitrate-N (mg -1)	<0.10	0.63
Total N (mg l^{-1})	40.60	1.69
Orthophosphate ion (mg l^{-1})	4.88	0.17
Orthophosphate -P (mg l^{-1})	1.59	0.06
Total P (mg l^{-1})	3.68	0.07
Chloride (mg l^{-1})	33.50	20.90
Sulphate (mg l^{-1})	62.40	33.50
Total floating matter (mg l^{-1})	80.00	6.00
Natrium (mg l^{-1})	276.00	22.60
Potassium (mg l^{-1})	6.51	3.00
Calcium (mg l^{-1})	18.80	47.10
Magnesium (mg l^{-1})	8.30	8.57

plant^{-1}) and Irr3 (4.8 number plant^{-1}). As for plant diameter, shoot length and root length did not show any differences among the treatments. As for results of shoot length and root length too, the highest values were caused by diluted effluent water plus gypsum (Irr2) treatment, but there were not any significant differences among the treatments (Table 4.). There was a significant difference between the Irr0 (7.83 g plant^{-1}) and Irr3 (3.87 g plant^{-1}) at the fresh root weight. The treatment of Irr0 resulted the maximum yield per plant (413 g plant^{-1}); the minimum was detected at Irr3 (261.5 g plant^{-1}). and no found significant difference among the treatments (Figure 1.). However, very strong positive correlation was calculated between the biomass and fresh root weight ($p = 0.01$; Pearson's $r = 0.84$). Based on our result purslane is not requires high amont of water.

Results of basil

As for the results of plant diameter and number of offshoots we could not prove the ef-

Table 4: Results of effect of irrigation treatments on purslane plant diameter (cm), number of branches (n./plant), shoot length (cm), root length (cm) (Szarvas, 2021)

Properties of purslane plant	Non irrigated control (Irr0)	Effluent water (Irr1)	Diluted effluent water+gypsum (Irr2)	Körös-oxbow water (Irr3)
Plant diameter (cm)	74.9±10.66 a	69.1±8.54 a	75.1±11.06 a	72.6±12.98 a
Number of offshoots (number plant^{-1})	8.7±2.83 b	7±3.13 ab	6.2±0.92 ab	4.8±1.4 a
Shoot length (cm)	38.85±6.16 a	38.6±4.02 a	39.64±5.59 a	37.53±5.37 a
Root length (cm)	20.7±3.91 a	21.8±1.69 a	22.25±3.23 a	18.9±3.54 a

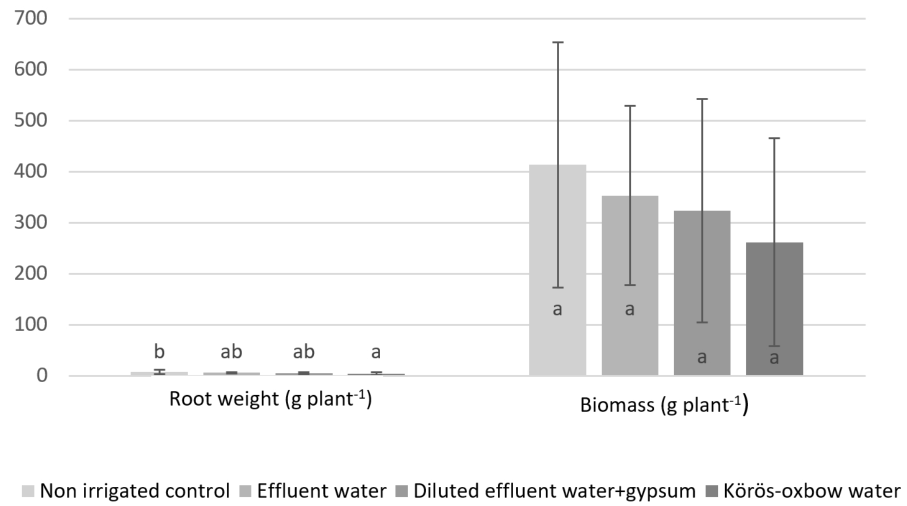

Figure 1: Yield results (biomass and root weight (g plant-1)) of common purslane (Szarvas, 2021)

fectiveness of the irrigation treatments; however, the Körös-oxbow lake water resulted the highest values (plant diameter: 30.05 ± 5.93 cm and number of offshoots: 15.6 ± 2.22 number plant^{-1}). In contrast, we could find significant differences between the Irr0 and Irr3 treatment at the plant height and root length. Although as for SPAD value the minimum (39.68 ± 2.07) was resulted by Irr3 treatment (Table 5.). Regarding the Körös oxbow water treatment (Irr3), in biomass (164 g plant^{-1}), fresh floral shoot tip (85.56 g/plant), fresh stem weight (78.44 g plant^{-1}) and fresh root weight (9.38 g plant^{-1}) the maximum yields were noted. In addition, very strong positive correlate was evinced between the biomass and fresh root weight ($p = 0.01$; Pearson's $r = 0.87$). The significantly more yield was achieved by irrigation on the basil. Based on our results, irrigation with undiluted effluent water from intensive fish farm is similarly effective to increase yield, as Irr3; because there was not significant difference between them (Figure 2.). The results of our experiment indicate that the irrigation help to achieve increased yield.

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Table 5: Results of irrigation treatments on basil plant height (cm), plant diameter (cm), number of offshoots (number plant-1), root length (cm) and SPAD value (Szarvas, 2021)

Properties of basil plant	Non irrigated control (Irr0)	Effluent water (Irr1)	Diluted effluent water+gypsum (Irr2)	Körös-oxbow water (Irr3)
Plant height (cm)	41.35±5.32a	44.3±4.64 ab	41.43±6.47 a	47.96±4.43 b
Plant diameter (cm)	29.9±5.1 a	28,77±4.86 a	24.34±4.6 a	30,05±5.93 a
Number of offshoots (number plant^{-1})	14.7±2.21 a	14.6±2.07 a	13.1±3.63 a	15.6±2.22 a
Root length (cm)	18.86±2.5 a	19.55±3.3 ab	19,13±3.54 a	23,22±3.3 b
SPAD value	47.14±4.72 c	41.26±2.81 ab	44.15±1.74 bc	39.68±2.07 a

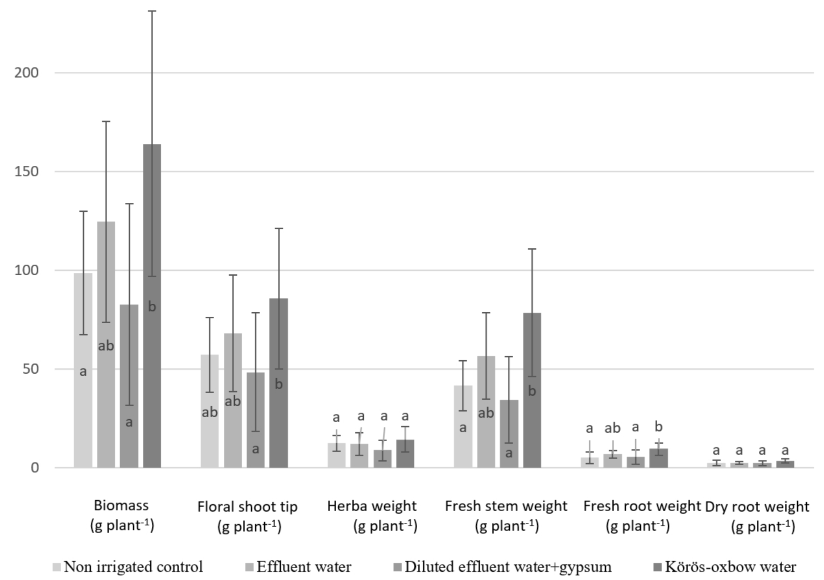

Figure 2: Different yield parameters (biomass, floral shoot tip, herba weight, fresh stem weight, fresh root weight and dry root weight (g plant-1) of garden basil with different irrigation types (Szarvas, 2021)

Discussion

Kafi and Rahimi (2011) published, salinity caused a reduction in purslane root and shoot growth (volume, area, diameter, total and main length and root dry weight). But we could not prove any significant effect of irrigation treatments neither on plant diameter nor on lenght of shoot or root. In our experiment on purslane, we detected that the increasing sodium caused decrasing fresh root weight only between the non-irrigated control treatment (Irr0) and the irrigated control treatment (Irr3). We could not prove significant differences among the irrigation treatments despite the result of Alam et al.

(2015) who published significant reduction of biomass caused by salinity stress, highest salinity level show more detrimental effects compared to the control. However, our results are contradicting to the report of He et al. (2021). Their experiment resulted that the maximum purslane yield was found at the level of 100 mM NaCl (equal to 230 mg Na) in contrast to our results.

Our results of basil is confirm the result of Heidari (2012), because the 22.6 mg l^{-1} (approximately 1 mmol Na) sodium content in Körös oxbow water irrigation (Irr3) increased the biomass yield of basil compared to the control treatment (Irr0) and (Irr2). But 276 mg l^{-1} (12 mM Na) sodium content of effluent water (Irr1) from intensive catfish farm decreased the biomass compared with the control treatment (Irr0), but the difference was not significant (Bernstein et al., 2010). According to Caliskan et al. (2017) the EC 0.4-0.8 dS m^{-1} and as for Maia et al. (2017) to EC 1.5 dS m^{-1} the basil tolerated the sodium. In our experiment EC 329-1380 μS cm^{-1} (Irr3: 0.0329 dS m^{-1} and Irr1:0.138 dS m^{-1}) of the irrigation water was morelower, than which was used by Caliskan et al. (2017) and Maia et al. (2017), so our effluent water can be used for basil irrigation.

Based on our results we can not agree with Omeir et al. (2019) because there were not any significant positive effects of effluent water irrigation neither on purslane nor on basil. We suggest, the application of irrigation to increase the yield of basil. Undiluted effluent water from intensive fishfarming (Irr1: biomass: 124.5 ± 51.01 g $plant^{-1}$) is similarly effective to increase yield of basil, like Irr3 (164 ± 67.2 g $plant^{-1}$); because there was not significant difference between them.

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