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AGRONOMIC PERFORMANCE OF THE LETTUCE CROP SUBJECTED TO DIFFERENT IRRIGATION LEVELS AND SOIL COVERINGS

DESEMPENHO AGRONÔMICO DA CULTURA DE ALFACE SUBMETIDA A DIFERENTES NÍVEIS DE IRRIGAÇÃO E COBERTURAS DE SOLO

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ABSTRACT: Levels of irrigation and soil cover can affect the dynamics of soil water and directly influence the agronomic performance of lettuce crops under protected cultivation. Given this context, the objective of this study was to evaluate the influence of different levels of irrigation and types of soil coverage on the agronomic performance of the Crespa lettuce cultivar 'Mônica', in the municipality of Jaboticabal-SP, Brazil. The experimental design was a completely randomized block in a 3 × 3 factorial scheme with four replications. To quantify the agronomic performance of the lettuce crop, selected morphological characteristics (plant height, stem diameter, head circumference, fresh aerial parts), productivity, and water use efficiency were measured at the time of harvest. We found that uncovered soil provided the best results with respect to plant height and head circumference of the curly lettuce cultivar 'Mônica' in protected cultivation when treatments were raised to 100% PwC at 17 days after transplanting. The level of irrigation corresponding to 100% PwC promoted larger stem diameters, fresh aerial parts, productivity and water-use efficiency when curly lettuce is grown in uncovered soil. Increasing the maximum water storage capacity of vessels at 17 days after transplanting crisp lettuce is assumed to favorably modify the agronomic performance of the crop, thereby influencing final productivity and the efficiency of water use.

Keywords: Lactuca sativa L., irrigation management, soil protection, productive potential.

RESUMO: Níveis de irrigação e coberturas de solo podem afetar a dinâmica de água no solo e influenciar diretamente no desempenho agronômico da cultura da alface crespa em cultivo protegido. Diante desse contexto, objetivou-se com este trabalho avaliar a influência da irrigação correspondente a diferentes níveis de irrigação e coberturas de solo no desempenho agronômico da cultivar de alface Crespa "Mônica", no município de Jaboticabal-SP. Empregou-se o delineamento experimental em blocos inteiramente casualizados, esquema fatorial 3 x 3, em quatro repetições. Para a quantificação do desempenho agronômico da cultura da alface, foram determinados, por ocasião da colheita, as características morfológicas, como: altura de plantas, diâmetro do caule, circunferência da cabeça, matéria fresca parte aérea, produtividade e eficiência do uso da água. O solo descoberto proporcionou os melhores resultados em altura de plantas e circunferência da cabeça da alface crespa cultivar 'Mônica' em cultivo protegido quando elevou-se os tratamentos a 100% CV aos 17 dias após o transplantio. O nível de irrigação referente a 100% CV promove maior diâmetro do caule, matéria fresca parte aérea, produtividade e eficiência do uso da água quando a alface crespa é cultivada em solo sem cobertura. A elevação da capacidade máxima de armazenamento de água no vaso aos 17 dias após o transplantio de mudas de alface crespa, altera o desempenho agronômico da cultura influenciando em sua produção final e na eficiência do uso de água.

Palavras-chave: Lactuca sativa L., manejo da irrigação, proteção do solo, potencial produtivo.

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INTRODUCTION

Lettuce (Lactuca sativa L.), which originates from the Mediterranean region, is one of the most widely cultivated leafy vegetables worldwide and is a common component in the daily diet of Brazilians, being consumed mainly in the fresh form, primarily in salads (SIMÕES et al., 2015). It is considered to have calming properties and, given that it is consumed raw, retains all the inherent nutritional properties (SANTANA et al., 2016).

According to Cassimiro et al. (2019), the predominant lettuce cultivars grown in Brazil are of the Crespa type, with a market share of 70%, followed by American (15%) and smooth (10%) cultivars, whereas other cultivars account for only 5% of the market.

Generally, soil moisture conditions have a pronounced influence on vegetable growth, with water scarcity being among the foremost factors limiting high productivity and the cultivation of high-quality products, whereas excess moisture can be equally detrimental (SANTANA et al., 2016). Accordingly, irrigation has become an important technology for ensuring high levels of crop productivity and quality (DELAZARI et al., 2017).

Irrigation in lettuce cultivation is of particular importance in areas characterized by irregularities in rainfall regimes, which substantially restricts crop development, even in the rainy season, when water deficiency can still occur due to increased evapotranspiration (MAGELLAN et al., 2015). As noted by Oliveira Filho et al. (2018), it is precisely this scenario of water scarcity, under the conditions of which, it is notoriously difficult to establish sustainable family agricultural production systems, that it is essential to develop technological strategies that enable a more dignified and less distressing coexistence with drought.

A further factor necessary for the good performance of lettuce is the management of irrigation relative to soil cover. Soils with either a synthetic or vegetable coverage facilitate a more efficient control of soil temperature and moisture, suppress the emergence of weeds, prevent evaporative water loss, and reduce the leaching of nutrients, thereby contributing to the enhanced utilization of water and nutrients by crops.

In studies conducted in the state of Rondônia, Brazil, examining the effects of different vegetable soil covers on lettuce crops, Carvalho et al. (2005) observed that soil coverage contributed to the production of higher average number of leaves and fresh matter mass, when compared with a bare soil control. Similarly, in Minas Gerais, during the spring–summer period, Andrade Júnior et al. (2005) obtained higher yields of the lettuce cultivars Elisa and Regina, grown in soils with a coverage of coffee hulls, whereas in Botucatu-SP, Pereira et al. (2000) and Verdial et al. (2000), obtained better production of lettuce cultivars Lucy Brown and Veronica, respectively, in soils with a coverage plastic film.

Given the importance of lettuce cultivation in protected environments in Brazil, it is imperative to conduct research that will contribute to maximizing the potential of this technology in regions of the country characterized by different climatic conditions, particularly studies that focus on appropriate irrigation management.

Accordingly, the objective of this study was to evaluate the influence of different levels of irrigation and types of soil cover on the agronomic performance of the lettuce cultivar ‘Mônica’ in the municipality of Jaboticabal-SP, with the aim of developing management practices beneficial to lettuce producers in this region.

MATERIAL AND METHODS

The study was conducted in the Plasticulture Sector of the Department of Engineering and Exact Sciences of FCAV/UNESP - Jaboticabal Campus (latitude 21°15′22″S and longitude 48°18′58″W), with an average altitude of 595 m above sea level. According to Köppen classification, the regional climate is an Aw type, namely, tropical, with dry winters and rainy summers, with an average annual temperature of 22.5°C (GARCIA; ANDRÉ, 2015). Data for the temperatures and humidities recorded during the course of the present study are presented in Figure 1.

During the experimental period, the temperatures recorded in a protected environment ranged from 37.4°C to 22.7°C, which are considered to be ideal for the cultivation of curly lettuce.

Comparatively, the ideal temperature for American lettuce is 23°C, although these can tolerate temperature of up to 29.4°C (HOTTA, 2008). Average humidity ranged from 79.1% to30.3%.

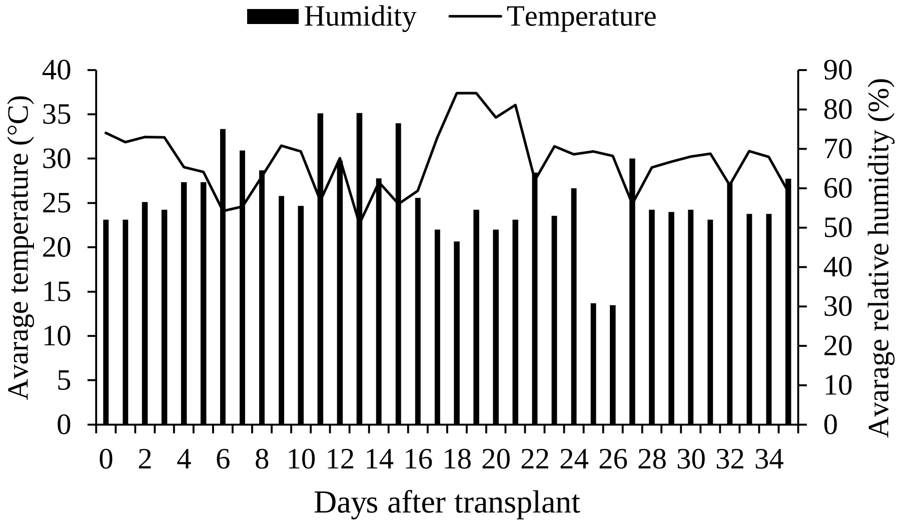


Figure 1. Variations in temperature variation (Tmédia) and relative humidity (Umédia) in a protected environment. UNESP, Jaboticabal – SP, 2021.

Lettuce plants were cultivated in 8-dm3 vases containing soil classified as a typical eutrophic Red Latosol, with clayey texture, moderate Horizon A, iron oxide content <8%, and a (SiO2)/ (Al2O3 + Fe2O3) ratio >0.75 (EMBRAPA, 2018), the chemical composition of which is shown in Table 1.

Table 1. Analysis of the soil in the experimental area. UNESP, Jaboticabal - SP, 2020.

pH	O.M	P	S	Ca	Mg	Na	K	Al	H+Al / SMP	S.B.	CTC
$CaCl_2$	g dm^{-3}	mg dm^{-3}		mmol$_c$ dm^{-3}							
5.4	27	203	43	39	13	-	6,0	1	18	57.9	76.1

*Athenas: Consulting and Laboratories. O.M: organic matter; S.B: sum of bases; CTC: cation exchange capability.

On the basis of our chemical analysis of soil, we performed transplant fertilization for lettuce culture, as recommended by IAC Bulletin 100 (VAN RAIJ et al., 1997). Specifically, we applied 20 kg ha-1 of N in the form of urea, 120 kg ha-1 of P2O5 in the form of simple superphosphate, and 60 kg ha-1 of K2O in the form of potassium chloride. For cover fertilization, we applied 60 kg ha-1 of N and 20 kg ha-1 of K2O, divided into three separate applications.

An irrigation level of 100% of the vase capacity (PwC) was obtained via saturation of the soil in vases and subsequent drainage, which we defined as the “vase capacity”, corresponding to the maximum amount of water that can be retained in the soil volume considered (CASAROLI; JONG VAN LIER, 2008). The mean value obtained for vessel water capacity (CV%) was 8.724 kg. The total depths water applied during the course of the experiment varied according to irrigation levels and presence or absence of coverage, with levels of 118.4, 149.8, 112.6, 227.6, 170.4, 114.6, 268.7, 170.6, and 125.4 mm corresponding to treatments T1, T2, T3, T4, T5, T6, T7, T8 and T9, respectively.

At 17 days after transplantation, all irrigation levels were elevated to 100% CV in order to verify the behavior of the crop after an elevation of soil water content.

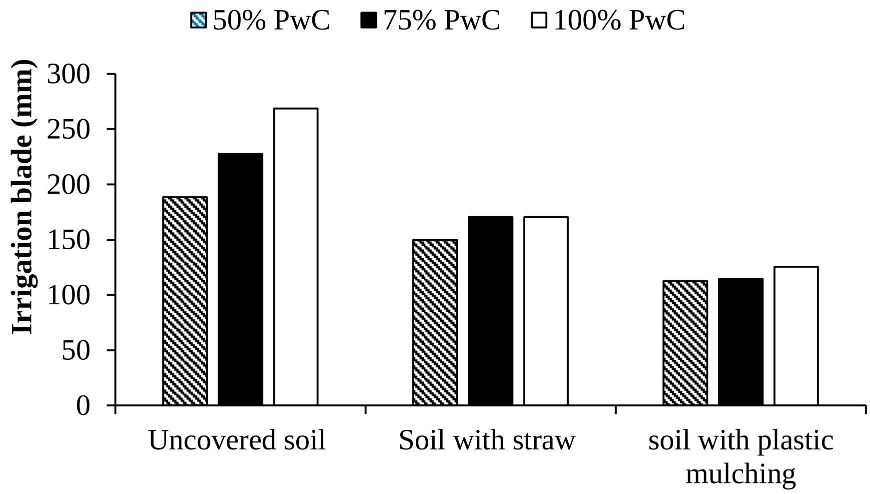


Figura 2. Irrigation depths applied to the curly lettuce crop in a protected environment. UNESP, Jaboticabal – SP, 2021.

The experimental design was one of completely randomized blocks, with a 3 × 3 factorial scheme and four replicates. In total, we performed the following nine irrigation/cover treatments: T1: irrigation level 50% PwC + soil without cover; T2: irrigation level 50% PwC + soil with straw; T3: irrigation level 50% PwC + soil with white mulching; T4: irrigation level 75% PwC + soil without cover; T5: irrigation level 75% PwC + soil with straw; T6: irrigation level 75% PwC + soil with white mulching; T7: irrigation level 100% PwC + soil without cover; T8: irrigation level 50% PwC + soil with straw; T9: irrigation level 100% PwC + soil with white mulching. For the treatments in which straw was used as a cover, 2,3 t ha-1 of dry Brachiaria grass was applied to the soil on the third day after transplanting. Evaluations were performed for each experimental unit, which corresponded to a single plant per vase, for which we measured the following parameters: plant height (cm), measured from soil level to the plant apex with the aid of a graduated ruler; stem diameter (mm), measured around the median region of the stem using a caliper; head circumference (cm), measured around the margins of the plant using a graduated ruler; fresh shoot matter (g plant-1), using plants cut close to the soil so that it was possible to remove the damaged leaves unsuitable for resale to consumers; productivity (ton ha-1), calculated from the fresh mass of each plant per vase and extrapolated to a hectare-based value; and water-use efficiency (kg m-3 of water) obtained from averages of the fresh masses of plants divided by the total water consumption during the cultivation cycle. The data were submitted to variance analysis using the F test ($P < 0.05$), with the means being compared with the Tukey test, using Agroestat statistical software, version 1.0 (BARBOSA; MALDONADO JÚNIOR, 2015).

RESULTS AND DISCUSSION

A summary of variance analysis (Table 2) indicated significant effects of the interaction between irrigation level and soil cover ($P < 0.01$) on stem diameter, fresh shoot mass, productivity, and water use efficiency of lettuces at 36 days after the transplantation of curly lettuce seedlings, and significant effect of irrigation level and soil cover ($P < 0.01$) on plant height and head circumference at 36 days after transplanting.

Table 2. Summary of variance analysis for plant height, stem diameter, head circumference, fresh aerial mass, productivity, and water-use efficiency of curly lettuce, as a function of irrigation levels and soil cover in a protected environment.

Evaluated parameters	Sources of variation			
	Irrigation levels (N_I)	Ground cover (C_S)	Interaction $N_I \times C_S$	CV (%)
Plant height	2.23^{ns}	17.70**	1.32^{ns}	18.55
Stem diameter	36.43**	47.54^{ns}	14.01**	5.08
Head circumference	3.39^{ns}	32.01**	1.60^{ns}	1.37
Fresh raw material aerial part	11.90**	48.90**	4.75**	27.61
Productivity	8.78**	37.70**	3.89*	15.97
Water Use Efficiency	56.37**	52.46**	4.13*	16.11

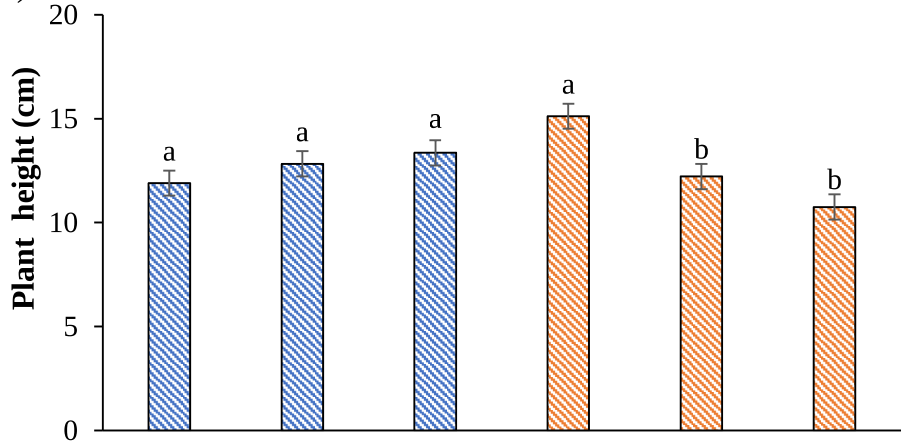
**Significant at the 1% level, as determined using the F test; *Significant at the 5% level, as determined using the F Test; ns: non-significant; CV (%): Coefficient of variation.

Figure 3 shows that the height and head circumference of curly lettuce plants were positively influenced by the uncovered soil treatment, with mean values of 15.12 cm and 26.66 cm, respectively.

These responses to an increase in irrigation can be ascribe to the fact that when grown in uncovered soils, plants tend to lose higher amount of water to the atmosphere, via both transpiration and evaporative loss from the soil. Moreover, for leafy vegetables, such as lettuce, the accumulation blade applied during the lettuce cycle has a considerable influence on the morphological responses of plants.

An adequate water supply even in uncovered soils, is conducive to an increase in leaf cell turgidity, division, and elongation, thereby giving rise to plants with greater vigor, along with adequate growth and head circumference (SCALON et al., 2011).

A)



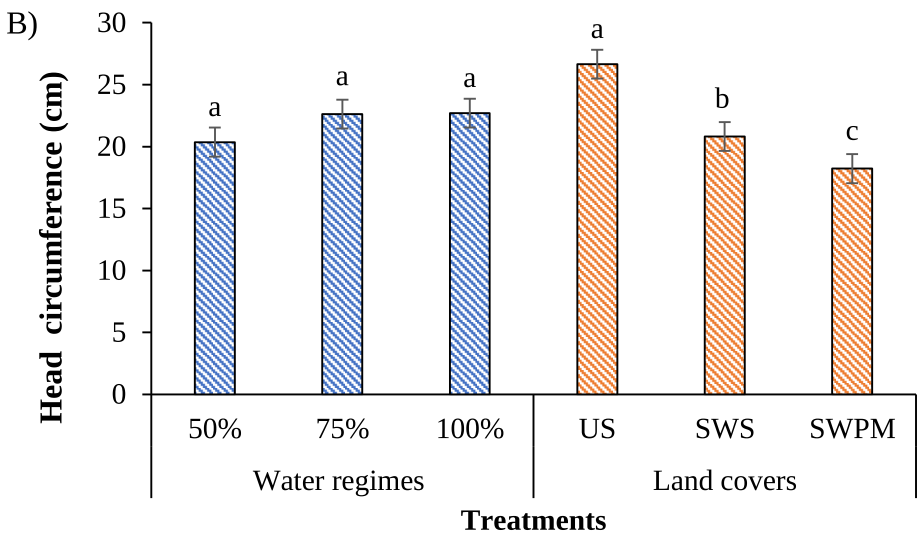
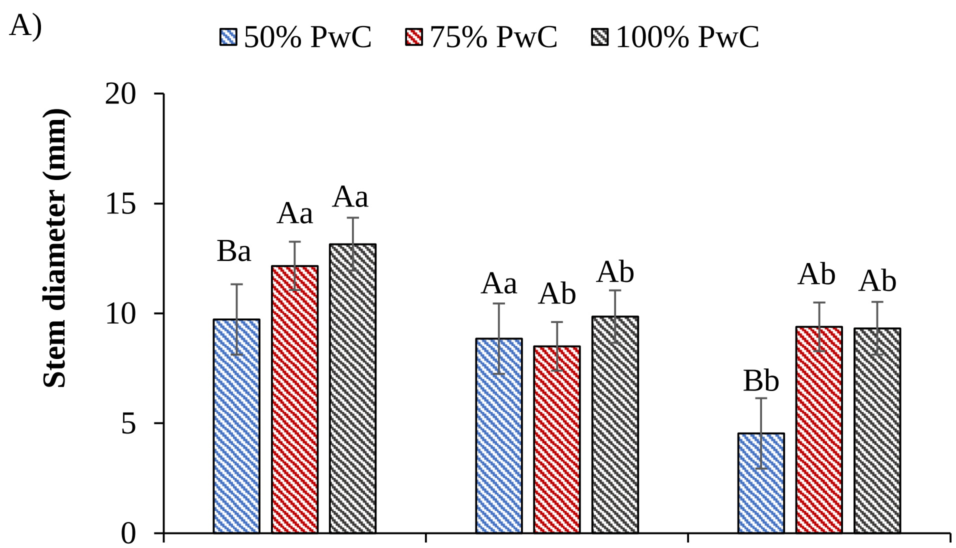


Figure 3. Plant height (A) and head circumference (B) of ‘Mônica’ curly lettuce as a function of irrigation levels and soil cover. US: uncovered soil; SWS: soil with straw; SWPM: soil with plastic mulching.

Figure 4 shows the significant interactive effects of irrigation level and soil cover ($P < 0.05$) on the mean values of stem diameter and fresh shoot matter for the Crespa lettuce cultivar ‘Monica’.

Higher mean stem diameter values of 12.16 cm and 13.15 cm were observed for seedlings cultivated in uncovered soil at irrigation levels of 75% and 100% PwC, respectively. Similarly, we obtained values of 115.10, 139.40, and 128.54 g plant-1 for fresh matter of the aerial parts of seedlings grown in uncovered soil at irrigation levels of 50%, 75%, and 100% PwC, respectively.



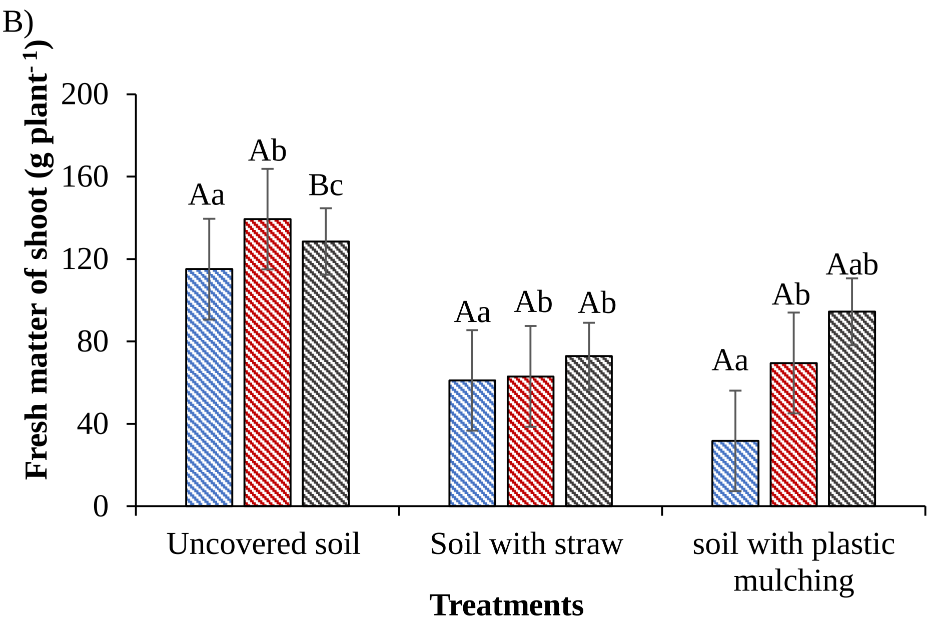


Figure 4. Stem diameter (A) and fresh shoot matter (B) of 'Mônica' curly lettuce as a function of irrigation levels and soil cover. Different uppercase letters indicate significant differences among irrigation levels, and different lowercase letters indicate significant differences among soil covers.

These increases in stem diameter and fresh shoot matter (Figure 4A and B) in response to increases in irrigation can mainly be attributed to the greater capacity of leaves to capture solar radiation in a protected environment, thereby enhancing the rate of photosynthesis (KERBAUY, 2012).

Larger stem diameters facilitate a greater accumulation of sap in curly lettuce plants, which in turn is reflected in a higher leaf production. Increasing the level of irrigation from 50% to 100% P_wC promoted an increase of fresh shoot matter, thereby enabling a greater capture of light energy by leaves and thus enhancing photosynthetic activity, with correspondingly elevated levels of photoassimilate accumulation. Significant effects of the interaction between irrigation level and soil cover ($P < 0.05$) were also detected with respect to the variables productivity (Figure 5A) and water-use efficiency (Figure 5B). Higher mean productivity values of 19.18, 21.42, and 23.23 t ha^{-1} were observed for lettuce cultivated in uncovered soil at irrigation levels of 50%, 75%, and 100% P_wC, respectively. Under conditions of appropriate irrigation management in vases in the absence of soil washing, nutrients within the soil are retained, and thus remain available for utilization by plants (VIANA et al., 2020), thus giving rise to higher yields, as observed for the curly lettuce examined in the present study.

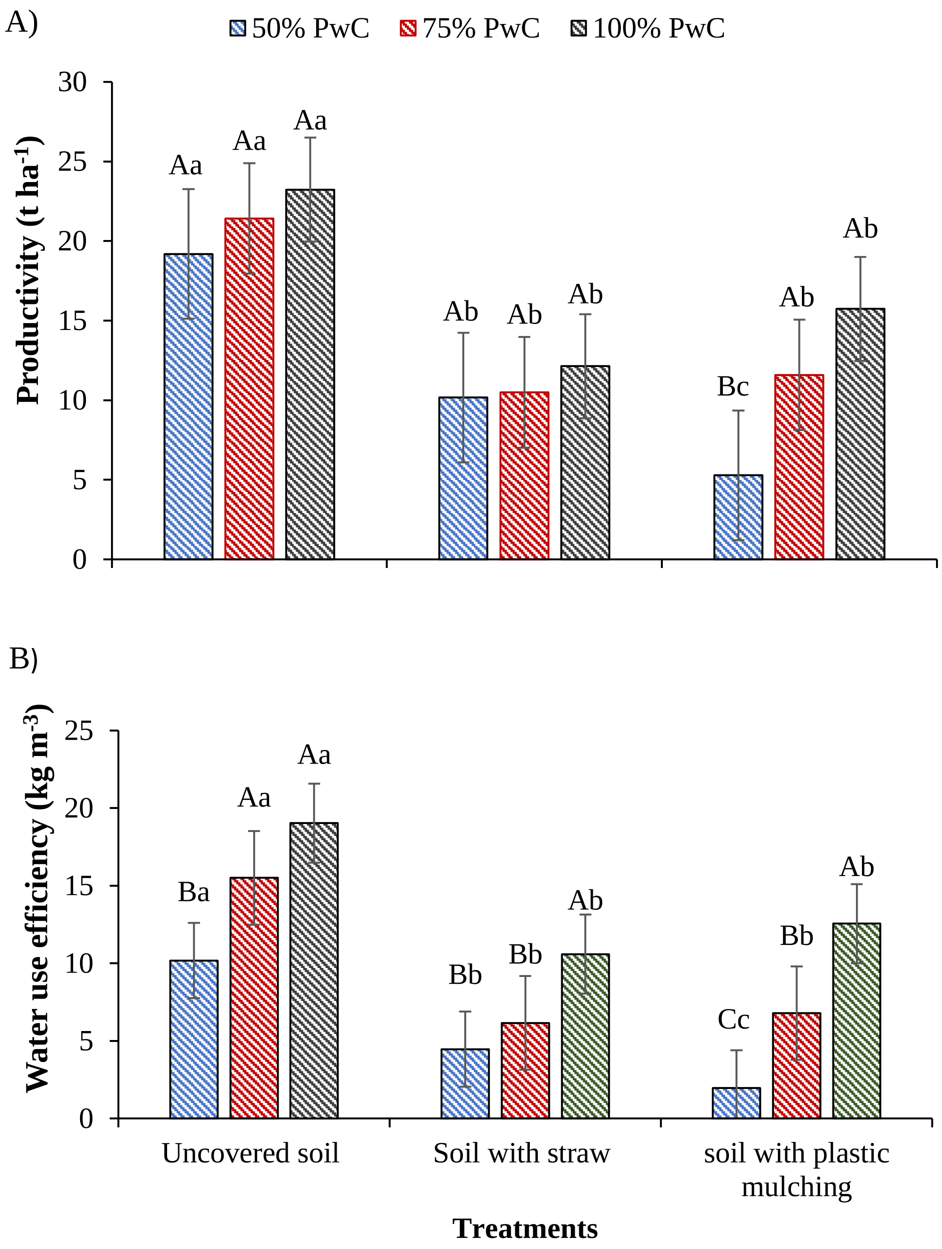


Figure 5. Productivity (A) and water use efficiency (B) of 'Mônica' curly lettuce as a function of irrigation levels and soil cover. Different uppercase letters indicate significant differences in irrigation levels, and different lowercase letters indicate significant difference in soil cover.

The efficiency of water use is reflected in the production of fresh matter (kg ha^{-1}) for a given amount of water applied (mm). In this study, we found that for lettuce seedlings cultivated in uncovered soil, water use efficiency increased with an increase in the level of irrigation, with values of 10.18, 15.51, and 19,03 kg m^{-3} being obtained at irrigation levels of 50%, 75%, and 100% P_wC, respectively. These findings tend to contrast with those previously reported by Sammis (1980), Andrade Júnior et al. (1992), and Hamada (1993). We suspect that these discrepant observations can be explained by the fact that we increased the irrigation level to maximum water capacity (100% P_wC) at day 17 after seedling transplantation, thereby conferring a greater cumulative irrigation depth for the uncovered soil (50% P_wC: 188.4 mm; 75% P_wC: 227.6 mm; 100% P_wC: 268.7 mm) regardless of the established irrigation levels. Our findings have particular relevance from the perspective of water conservation, which is of fundamental importance with respect to the development of appropriate technologies adapted to regions in which there is scarcity of water resources (MENEZES JÚNIOR; ALBUQUERQUE, 2004). Moreover, by determining variations in the water consumption of crop plants at different stages of development, we can gain valuable insights into the underlying physiological processes, as well as their consequences.

CONCLUSION

Under the edaphoclimatic conditions imposed in the present study, we established that among the soil coverage treatments for protected cultivation of the Crespa lettuce cultivar Monica, uncovered soil provided the best results with respect to plant height and head circumference, when irrigation levels were increased by 50% PwC and 75% PwC in the experiment at 100% PwC.

Similarly, when Crespa lettuce is grown in uncovered soil, an irrigation level of 100% PwC promotes greater stem diameter, fresh shoot matter, productivity, and water-use efficiency.

Increasing the water storage capacity of vessel to maximum values at 17 days after transplanting lettuce seedlings may contribute to modifying the morphological behavior of the crop, thereby influencing its final production and the efficiency of water use.

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