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Water consumption and sugar beet crop formation with various irrigation and fertilization methods

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ABSTRACT

The article presents the results of field experiments conducted on meadow-serozem soils of the foothill irrigated zone in Southern Kazakhstan. The study aimed to evaluate the characteristics of water consumption and sugar beet yield formation under different irrigation methods and fertilizer applications. The experiments investigated the influence of irrigation techniques and fertilization on crop productivity and water use efficiency. The results showed that sugar beet yield formation largely depends on the applied irrigation method and nutrient management. The highest irrigation water consumption per unit of yield was observed under sprinkler irrigation. At the same time, the efficiency of irrigation and fertilization practices varied depending on the biological characteristics of the cultivated sugar beet hybrids. The obtained results demonstrate the importance of optimizing irrigation technologies and fertilizer application to improve water use efficiency and ensure stable yields of sugar beet under irrigated conditions in the foothill zone of Southern Kazakhstan.

Keywords: Sugar beet, Hybrids, Irrigation methods, Subsurface drip irrigation, Fertilization, Yield, Water consumption.
Article type: Research Article.

INTRODUCTION

Kazakhstan's high dependence on sugar imports significantly reduces its economic and food security, as the annual volume of sugar purchases increases pressure on the accumulation of foreign exchange resources and stimulates foreign rather than domestic producers. In recent years, the volume of imports of major food products has amounted to about one billion US dollars. Sugar, including raw sugar, accounted for the largest share (about 30%) of imports (KazAgro 2014; Al-Ghobari & Dewidar 2018). Therefore, ensuring the country's population with sugar primarily produced from domestic raw materials is a state priority, allowing the problem of food security to be addressed and providing food industry enterprises with the necessary components. Sugar beet is a plant with increased water requirements due to its long growing season and high yield potential. The full use of its yield potential, as well as the applied agrotechnical treatments, including nitrogen fertilizers, depends on many factors, including the genetic diversity of hybrids (Tarkalson *et al.* 2014; Hoffmann & Loel 2015*)* and the adaptability of varieties to individual habitats (Studnicki *et al.* 2019), but to the greatest extent it depends on the type or location of the soil and, above all, depending on the availability of water during the period of increased plant demand (Podlaski *et al.* 2017; Prasher *et al.* 2023; Rehman *et al.* 2024). The availability of water for plants depends on the amount of precipitation and its distribution during the growing season, and in the case of lack of precipitation, if possible, depends on irrigation. Some studies of irrigation methods (Borówczak & Grześ 2002; Rzekanowski *et al.* 2005) have shown that sugar beet reacts to sprinkling by increasing the yield of root crops, but by reducing

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the sugar content. Numerous studies, mainly conducted abroad, show that drip irrigation of crops is the most effective way of rational use of irrigation water. Drip irrigation is a method of irrigation in which water is supplied in small portions evenly to the roots of the plant throughout the growing season and irrigation moisture is supplied only to the plants, and is not consumed between the rows. Due to this, the drip irrigation system is more efficient than other irrigation methods (Sharmasarkar *et al.* 2001; Ramazan Topak 2011; Kiymaz & Ertek 2015). The effectiveness of using mulching films during drip irrigation in preserving moisture and controlling weeds has been proven (Seyfi & Rashidi 2007; Raina *et al.* 2013). In recent years, we have conducted studies to evaluate the efficiency of drip irrigation for field crops on irrigated lands in the southern and southeastern regions of Kazakhstan, including rice, sugar beet, maize, and soybean. The research results demonstrated the high efficiency of drip irrigation in the cultivation of highly water-demanding field crops such as rice and sugar beet (Kenenbayev *et al.* 2016; Ospanbayev *et al.* 2025; Ospanbayev *et al.* 2025a; Sembayeva *et al.* 2025). However, surface drip irrigation has not been widely adopted by farmers in Kazakhstan. The main reasons for this are the significant costs associated with the annual installation and removal of drip irrigation tapes, as well as considerable difficulties in the timely implementation of agrotechnical practices. Subsurface drip irrigation provides more precise use of resources by delivering water directly to the active root zone of plants compared to the surface drip irrigation (Ayars *et al.* 1999; Wang H. *et al.* 2022). Unlike surface drip irrigation, subsurface drip irrigation systems have a longer service life, lead to reduced weed infestation in crops, and facilitate soil preparation and other tillage operations. Subsurface drip irrigation currently represents a relatively small component of irrigation systems, but it is gradually gaining wider recognition. The main advantages of subsurface drip irrigation include more efficient water use, as surface evaporation, runoff, and deep percolation losses can be reduced or almost eliminated. Subsurface drip irrigation also facilitates the use of lower-quality water due to increased irrigation frequency, which minimizes matric and osmotic stress. In the case of treated wastewater, it also reduces pathogen movement, odors, and contact with animals and humans. Agronomic advantages include improved plant growth, higher yields, and better product quality due to the timely supply of water and nutrients directly to the crop root zone (Al-Ghobari & Dewidar 2018). Subsurface drip irrigation installed at a depth of 40 cm has been shown to reduce water consumption and increase water productivity when irrigation water is applied according to crop water requirements (Çetin & Kara 2019). Alternating plant placement within rows under subsurface drip irrigation can significantly increase the emergence rate of maize, promote seedling growth, and improve yield, water use efficiency, and partial factor productivity of nitrogen, particularly in arid and semi-arid regions (Mo *et al.* 2017). Since subsurface drip irrigation systems are installed below the soil surface, weed germination and growth are significantly reduced, especially in the inter-row spaces. In some regions, the possibility of obtaining two harvests per year is ensured compared to the surface drip irrigation, as there is no need to remove drip lines during harvesting and reinstall them before sowing. Agricultural operations and field management are facilitated because the drip laterals are buried in the soil, minimizing damage caused by agricultural machinery and field operations. In addition, vehicle movement directly above the drip tubes or tapes should be avoided. During drip fertigation, the application of fertilizers directly into the active root zone reduces nutrient losses caused by leaching or volatilization (in the case of nitrogen) and increases fertilizer use efficiency (Xu. *et al.* 2019). It has been established that the efficiency of N, P, and K utilization under drip fertigation reaches 90%, 45%, and 80%, respectively, compared to 30–50%, 20%, and 50% under conventional soil application (Sembayeva A. *et al.* 2025). Improved fertilizer use efficiency means that similar crop yields can be achieved with lower fertilizer application rates. More efficient management of water and nutrients also reduces potential environmental risks associated with nutrient losses (Raina *et al.* 2013). Thus, subsurface drip irrigation combined with fertigation represents an effective technological solution for improving water and nutrient use efficiency in irrigated agriculture. This irrigation method ensures the precise delivery of water and fertilizers directly to the plant root zone, reduces water losses due to evaporation and deep percolation, and increases crop productivity. In addition, subsurface drip irrigation reduces weed infestation, facilitates field management operations, and allows more efficient use of fertilizers by minimizing nutrient losses. The application of this technology contributes to higher yields, improved water productivity, and reduced environmental risks associated with irrigation and fertilization practices.

MATERIALS AND METHODS

Field studies were conducted in the beet-growing area of Southern Kazakhstan on the fields of Zhylybulak-Merke LLP, located in the Merke district of the Zhambyl region, which belongs to a very arid foothill agro-climatic zone.

The sum of effective temperatures reaches 3000–3500 °C, while the annual precipitation ranges from 300 to 400 mm. A production field experiment to evaluate sugar beet hybrids under different irrigation and fertilization methods on meadow-serozem soils was carried out according to the following scheme:

Hybrids	**Irrigation methods**	**Methods of fertilization**
1. Aksu (Kazakhstan) 2. Taraz (Kazakhstan) 3. Recordina (KWS)	1. Drip irrigation 2. Subsurface drip irrigation 3. Sprinkling	1. Ammophos 200 kg ha^{-1} for basic processing – background 2. background + ammonium nitrate 100 kg ha^{-1} in the first top dressing (background +AN100) 3. background + ammonium nitrate 100 kg ha^{-1} in the first dressing+100 kg ha^{-1} in the second dressing (background + AN 200) 4. background+ammonium nitrate 100 kg ha^{-1} in the first dressing+100 kg ha^{-1} in the second dressing+100 kg ha^{-1} in the third dressing (background + AN 300)
The area of the plots is 1200 m^2 (24 × 50), the repetition is threefold.		

Ammonium phosphate (ammophos) at a rate of 200 kg ha^{-1} was applied as a baseline fertilizer in autumn by broadcasting with a RUM-4 fertilizer spreader before deep plowing. Ammonium nitrate, according to the experimental design, was applied as a top dressing through fertigation simultaneously with drip irrigation at the following stages:
first top dressing at the 2–3 true leaf stage;
second top dressing at the stage of leaf closure within the row;
third top dressing at the stage of leaf closure between rows.
For the calculation of the water consumption coefficient, the following indicators were used:
2024: irrigation rate 5000 m³ ha^{-1}, pre-irrigation soil moisture 1050 m³ ha^{-1}, precipitation during the growing season 1020 m³ ha^{-1}. Total water supply amounted to 7070 m³ ha^{-1}.
2025: irrigation rate 5000 m³ ha^{-1}, pre-irrigation soil moisture 950 m³ ha^{-1}, precipitation during the growing season 970 m³ ha^{-1}. Total water supply amounted to 6920 m³ ha^{-1}.
At harvest, sugar beet yield was measured as the amount of sugar beet produced per hectare (kg ha^{-1} or tons ha^{-1}). Yield is the primary economic output and a key indicator of the success of the different treatments.
The collected data were subjected to appropriate statistical analyses to determine the significance of the effects of sowing method and drip tape sealing on the measured variables. Analysis of variance (ANOVA) was used to assess the main effects and interactions of the experimental factors. Where significant differences were found, post-hoc tests, such as Tukey's HSD test, were employed to compare means. The paper mentions "HCP (c ha^{-1})" in Table 1, which is the Least Significant Difference (LSD). This statistic was used to compare the yields. Statistical software was used for the analysis.

RESULTS AND DISCUSSION

To evaluate the effect of irrigation methods and fertilizer application on sugar beet productivity, a comparative study was conducted using three irrigation systems: surface drip irrigation, subsurface drip irrigation, and sprinkler irrigation. The experiment included three hybrids—Aksu, Taraz, and Recordina—subjected to different fertilizer treatments: baseline application (background) and baseline plus ammonium nitrate (AN) at rates of 100, 200, and 300 kg ha^{-1}. This design allowed for the assessment of the interactive effects of irrigation and fertilization on yield formation over two consecutive growing seasons (2024–2025). The results of these treatments are summarized in Table 1, providing insight into the influence of irrigation technology and nutrient management on the productivity of different sugar beet hybrids under the specific agro-climatic conditions of southern and southeastern Kazakhstan. Table 1 presents the sugar beet yield (ton ha^{-1}) of different hybrids depending on the irrigation method and fertilizer application during 2024–2025. Three irrigation methods were compared: drip irrigation, subsurface drip irrigation, and sprinkler irrigation. Fertilizer treatments included a baseline application (background, "фон") and the baseline plus ammonium nitrate at rates of 100, 200, and 300 kg ha^{-1} (фон + AC100, фон + AC200, фон + AC300). The results show that subsurface drip irrigation generally provided the highest yields across all hybrids, followed by surface drip irrigation and sprinkler irrigation. Among the tested hybrids, Recordina demonstrated the highest productivity under all treatments, while Аксу and Тараз showed moderate yields. Increasing fertilizer rates from 100 to 300 kg ha^{-1} significantly enhanced yields, with the most pronounced response observed under subsurface drip irrigation. In 2024, the highest yield (97.3 tons ha^{-1}) was recorded for Recordina under subsurface drip irrigation with the highest fertilizer rate (фон + AC300). In 2025, similar trends were observed, although absolute yields were slightly lower due to climatic variations. The mean yield over two years confirmed the superiority of subsurface drip irrigation combined with higher fertilizer doses, highlighting the importance of integrating optimized irrigation and nutrient management for maximizing sugar beet productivity.

The least significant difference (LSD) for yield at $p \leq 0.05$ ranged from 3.6 to 4.1 tons ha^{-1}, indicating statistically reliable differences between treatments.

Table 1. Sugar beet yield of hybrids depending on irrigation method and fertilizer application (ton ha^{-1})

Irrigation methods	Hybrids	Methods of fertilization			
		background	**background+AN100**	**background+AN200**	**background+AN300**
		2024			
Drip irrigation	Aksu	56.3	67.4	76.2	78.8
	Taraz	53.7	65.3	77.0	77.2
	Recordina	70.2	79.0	83.7	86.8
Subsurface drip irrigation	Aksu	60.2	66.0	80.5	79.0
	Taraz	64.2	70.2	80.7	82.2
	Recordina	71.7	80.2	96.2	97.3
Sprinkling	Aksu	50.2	55.7	62.5	66.6
	Taraz	52.2	60.1	62.2	64.8
	Recordina	65.9	72.2	78.4	82.2
LSD (ton ha^{-1})		4.1			
		2025			
Drip irrigation	Aksu	47.6	55.8	59.7	64.6
	Taraz	50.1	58.8	63.3	63.6
	Recordina	63.2	68.1	76.3	82.3
Subsurface drip irrigation	Aksu	50.5	56.7	63.7	65.0
	Taraz	50.8	54.5	58.2	62.2
	Recordina	66.6	75.3	80.6	88.5
Sprinkling	Aksu	40.2	44.2	48.8	52.0
	Taraz	40.6	43.3	47.0	50.9
	Recordina	52.3	56.7	60.6	63.3
LSD (ton ha^{-1})		3.6			
		The average for 2024-2025			
Drip irrigation	Aksu	52.0	61.6	68.0	71.7
	Taraz	51.9	62.1	70.2	70.4
	Recordina	66.7	73.6	80.0	84.6
Subsurface drip irrigation	Aksu	53.4	61.4	72.1	71.7
	Taraz	57.5	62.4	69.5	72.2
	Recordina	69.2	77.8	88.4	92.9
Sprinkling	Aksu	45.2	50.0	55.7	59.3
	Taraz	46.4	51.7	54.6	57.9
	Recordina	59.1	64.5	69.5	72.8
LSD (ton ha^{-1})		3.6-4.1			

Fig. 1 shows the water consumption coefficient (m³ ton^{-1}) for three sugar beet hybrids—Aksu, Taraz, and Recordina—under different irrigation methods: drip irrigation, subsurface drip irrigation, and sprinkler irrigation. For each irrigation method, four fertilizer treatments are presented: baseline application (background) and baseline plus ammonium nitrate at rates of 100, 200, and 300 kg ha^{-1} (background + AN 100, 200, and 300).

The results indicate that the lowest water consumption per unit of yield was observed for the Recordina hybrid under all irrigation methods, particularly under subsurface drip irrigation combined with the highest fertilizer dose (background + AN 300). The highest water consumption was recorded for Aksu and Taraz under sprinkler irrigation. Subsurface drip irrigation demonstrated the most efficient use of water compared with surface drip irrigation and sprinkling, reducing the volume of water required to produce one ton of sugar beet. Error bars in the figure represent standard deviation, illustrating the variability of the data.

CONCLUSION

In the conditions of irrigation in South Kazakhstan, the effectiveness of sugar beet cultivation significantly depends on both irrigation and fertilizer methods, as well as on cultivated hybrids. Under irrigation conditions, the formation of high sugar beet yields is primarily influenced by nitrogen fertilization methods, followed by cultivated hybrids and irrigation methods. At the same time, the amount of water consumption by a sugar beet plant depends more on irrigation methods, followed by cultivated hybrids and fertilization methods.

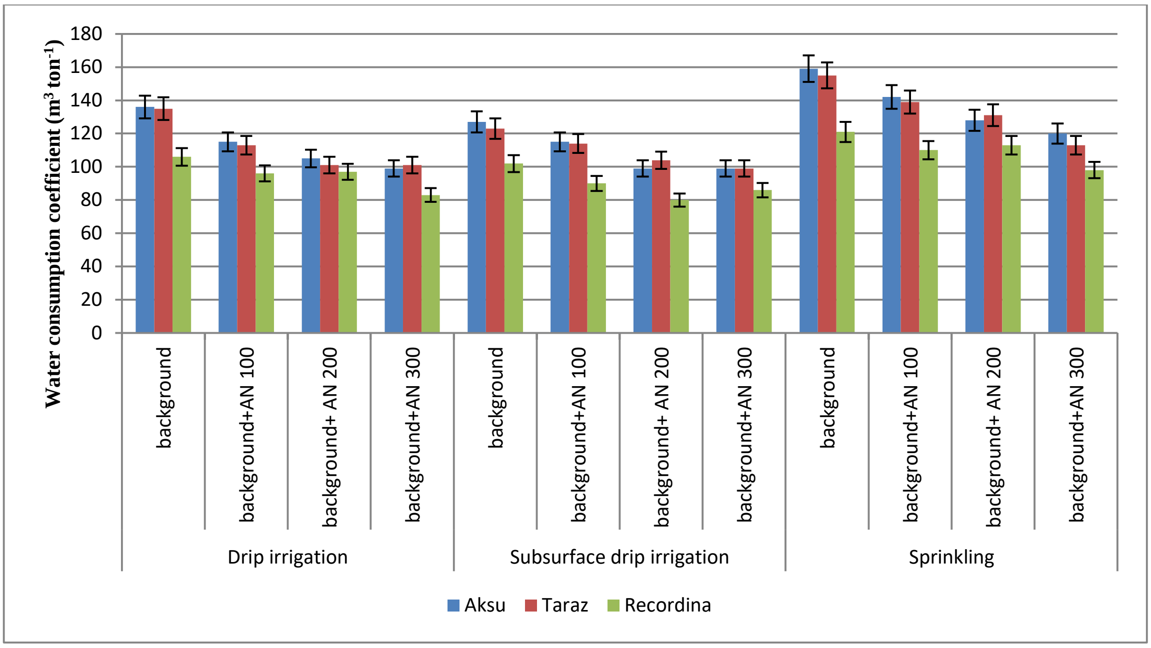

Fig. 1. Water consumption coefficient (m³ ton^{-1}) of sugar beet hybrids depending on irrigation method and fertilizer application (average for 2024-2025).

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REFERENCES

Al-Ghobari, MH & Dewidar, AZ 2018, Integrating deficit irrigation into surface and subsurface drip irrigation as a strategy to save water in arid regions. *Agricultural Water Management*, 209: 55-61.

Analytical collection of the sugar market 2014, *KazAgro*, 20 p.

Ayars, JE, Phene, CJ, Hutmacher, RB, Davis, KR, Schoneman, RA, Vali, SS & Mead, RM 1999, Subsurface drip irrigation of row crops: A review of 15 years of research at the water management research laboratory. *Agricultural Water Management*, 42: 1-27.

Borówczak, F & Grześ, S 2002, The influence of irrigation, foliar fertilization and nitrogen application on root yields and economic effects of sugar beet cultivation. *Biuletyn Instytutu Hodowli i Aklimatyzacji Roślin* (*Online*), 222: 204-213, [In Polish].

Çetin Oner, Kara Abdurrahman. Assesment of water productivity using different drip irrigation systems for cotton. *Agricultural Water Management.* Volume 223, 20 2019, https://doi.org/10.1016/j.agwat.2019.105693

Hoffmann, C.M.; Loel, J. 2015, Bedeutung der züchtung für den ertragsanstieg von zuckerrüben. *Sugar Ind.* 140, 48-56.

Hussein M. Al-Ghobari, Ahmed Z. Dewidar Integrating deficit irrigation into surface and subsurface drip irrigation as a strategy to save water in arid regions. *Agricultural Water Management*. Vol. 209, 2018, P. 55-61.

Chmura, K.; Chylińska, E.; Dmowski, Z.; Nowak, L. 2009, Role of the water factor in yield formation of chosen field crops. Infrastruct. *Ecol. Rural Areas* 9: 33–44. [In Polish].

Kenenbayev, S., Ospanbayev Zh., Kydyrov A., Musagodzhaev N. and Aristangulov S. 2016, Effectiveness of Sugar Beet Cultivation under Drop Irrigation in South-East Kazakhstan. *Biosciences Biotechnology Research Asia*, 13(2): 917-924, http://dx.doi.org/10.13005/bbra/2115

Kiymaz, S & Ertek, A 2015, Water use and yield of sugar beet (*Beta vulgaris* L.) under drip irrigation at different water regimes. *Agricultural Water Management*, 158: 225-234, https://doi.org/10.1016/j.agwat.2015.05.005.

Mo, Y, Li, G & Wang, D 2017, A sowing method for subsurface drip irrigation that increases the emergence rate, yield, and water use efficiency in spring corn. *Agricultural Water Management*, 179: 288-295, https://doi.org/10.1016/j.agwat.2016.06.005.

Ospanbayev ZH, Doszhanova A, Sembayeva A, Ilmaliyeva G, Batyrkhanov M, Aimbetova E, Raiymbekova I, Amanbay B 2025, Formation of a sugar beet crop with subsurface drip irrigation, depending on the methods of sowing and sealing the drip tape. *Caspian Journal of Environmental Sciences,* 23 (2): 437-446, http://doi.org/10.22124/cjes.2025.8758.

Ospanbayev ZH, Doszhanova A, Sembayeva A, Myrzabaeva G, Tuyakbayeva A, Ualiyeva R, Zhangazin S, Arynova SH 2025a, Water consumption of rice depending on the methods of its cultivation and irrigation. *Caspian Journal of Environmental Sciences,* 23 (3): 685-690, http://doi.org/10.22124/cjes.2025.8945.

Podlaski, S, Chołuj, D & Wiśniewska, A 2017, Development of sugar beet yield in relation to selected environmental conditions, *Zeszyty Problemowe Postepow Nauk Rolniczych*, 590: 59-71 [In Polish].

Prasher, P, Sharma, M, Singh, SK, Gulati, M, Chellappan, DK, Rajput, R, Gupta, G, Ydyrys, A, Kulbayeva, M, Abdull Razis, AF & Modu, B 2023, Spermidine as a promising anticancer agent: Recent advances and newer insights on its molecular mechanisms. *Frontiers in Chemistry*, 11: 1164477.

Rehman, G, Muhammad, J, Ilyas, M, Subhanullah, M, Ullah, K, Massimzhan, M, Toktar, M Bektay, Y, Kalybekov, M, Ydyrys, A & Zhakypbek, Y 2024, Phytoremediation of heavy metals from soil and their effects on plant physiology-A review. *ES Materials & Manufacturing*, 26: 1298.

Raina, JN, Suman, S, Kumar, P & Sephia, RS 2013, Effect of drip fertigation with and without mulch on soil hydrothermal regimes, growth, yield, and quality of apple (*Malus* × *domestica* Borkh.). *Communications in Soil Science and Plant Analysis*, 44: 2560-2570.

Ramazan Topak, Sinan Süheri & Bilal Acar Effect of different drip irrigation regimes on sugar beet (*Beta vulgaris* L.) yield, quality and water use efficiency in Middle Anatolian, Turkey//Irrigation Science volume 29, pages79–89 (2011).

Rzekanowski, C, Żarski, J, Dudek, S, Rolbiecki, S, Rolbiecki, R 2005, Irrigation as a countermeasure for sugar beet yield decreases during dry years on light soils. *Water Environ. Rural Areas*, *5*: 287–300. (In Polish).

Cassel Sharmasarkar FC, Sharmasarkar S, Miller SD, Vance GF, Zhang R (2001a) Assessment of drip and flood irrigation on water and fertilizer use efficiencies for sugar beets. *Agricultural Water Management*, 46:241–251.

Seyfi K, Rashidi M 2007, Effect of drip irrigation and plastic mulch on crop yield and yield components of Cantaloupe.Int. *J. Agric. Biol.*, 9 (2).

Sembayeva A, Ospanbayev ZH, Doszhanova A, Bekbauov M. Saikenova A, Myrzabek K, Kanatkyzy M, Abildayeva D 2025, Contamination of crops and productivity of rice in various ways of its aerobic cultivation and irrigation. *Caspian Journal of Environmental Sciences,* 23 (2): 397-407, http://doi.org/10.22124/CJES.2025.8722.

Sembayeva A, Ospanbayev ZH, Zhapayev RK, Kenenbayev SB, Pejic B, Kunypiyaeva GT, Doszhanova AS, Bekbauov M 2025, Corn hybrids assessment for grain yield under the soil tillage regimes and drip irrigation in southeast Kazakhstan. *SABRAO Journal of Breeding and Genetics,* 57 (1): 46-55, pISSN 1029-7073; eISSN 2224-8978 http://doi.org/10.54910/sabrao2025.57.1.5.

Singandhupe, RB, Rao, GGSN, Patil, NG, Brahmanand, PS 2003, Fertigation studies and irrigation scheduling in drip irrigation system in tomato crop (Lycopersicon esculentum L.) // *Eur. J. Agron.*, 19: 327-340.

Studnicki, M, Lenartowicz, T, Noras, K, Wójcik-Gront, E, Wyszyński, Z 2019. Assessment of stability and adaptation patterns of white sugar yield from sugar beet cultivars in temperate climate environments. *Agronomy* 2019, 9.

Tarkalson, D, Eujay, I, Beyer, W, King, BA drought tolerance selection of sugarbeet hybrids. *J. Sugar Beet Res.* 2014, 51, 14–30.

Wang, H, Wang, N, Quan, H, Zhang, F, Fan, J, Feng, H, Cheng, M, Liao, Z, Wang, X, Xiang, Y 2022, Yield and water productivity of crops, vegetables and fruits under subsurface drip irrigation: a global meta-analysis. *Agricultural Water Management,* 269, http://doi.org/10.1016/j.agwat.2022.107645.

Xu, J, Caia, H, Wang, X, Ma, C, Lu, Y, Ding, Y, Wang, X, Chen, H, Wang, Y & Saddique, Q 2019, Exploring optimal irrigation and nitrogen fertilization in a winter wheat summer maize rotation system for improving crop yield and reducing water and nitrogen leaching. *Agricultural Water Management,* Vol. 228, http://doi.org/10.1016/j.agwat.2019.105904.

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