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Research Article
Effect of Indirect Subsurface Dripper Discharge on Fruit Growth and Quality of Jujube

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Abstract
Background: Drought restricts the development of characteristic forestry and fruit industry, such as jujube in South Xinjiang, China. This problem could be addressed with some efficient water-saving irrigation methods. Particularly, Indirect Subsurface Drip Irrigation (ISDI) is an effective irrigation method for water-conservation. Dripper discharge is an important design parameter for such irrigation. **Methodology:** To study the appropriate dripper discharge for jujube in South Xinjiang under ISDI, the influence of three dripper discharge levels (2, 3 and 4 L h^{-1}) on the fruit growth and quality of jujube were quantitatively studied through field plot experiment. **Results:** Results showed that dripper discharge affected on water transport in the wetting front and on the fruit growth and quality of jujube and the water use efficiency, the sugar content in fruit was the highest in the 2 L h^{-1} treatment, being 46.62% significantly higher than that in the 3 and 4 L h^{-1} treatments. The contents of organic acid and soluble protein of fruit in the 2 and 3 L h^{-1} treatments were significantly higher than in the 4 L h^{-1} treatment. Water use efficiency was also highest in the levels 2 L h^{-1}, being 3.44 kg m^{-3} increased by 14.29% compared with that of the treatment 4 L h^{-1}. **Conclusion:** Small dripper discharge was conductive to promote the growth of jujube, improving the fruit quality and increasing the yield of jujube and water use efficiency, which was the appropriate dripper discharge for jujube.

Key words: Jujube tree, yield, fruit quality, water use efficiency, dripper discharge, indirect subsurface drip irrigation

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Jujube trees are one of special fruit trees in China called Chinese jujube (*Zizyphus jujuba* Mill.) abroad. Jujubes belong to *Ziziphus* Mill., plant of Rhamnaceae[1]. As a kind of special fruit tree resource and distinctive dominant tree species, jujube trees are characterized by easy cultivation, strong adaptability, bearing fruit early, quick gains and good market prospect. Southern Xinjiang of China belongs to extreme arid region, jujubes have better quality equipped with unique climate characteristics in the region and however drought restricts the development of jujube as the scale and the industrialization. How to determine the suitable water-saving irrigation technology for local jujube to improve the fruit growth and quality of the jujube and irrigation water use efficiency are worth studying topics.

Indirect Subsurface Drip Irrigation (ISDI) is a highly efficient water-saving irrigation technology which is firstly originated from Sand Tube Irrigation (STI) proposed by Meshkat[2]. It's composed of common surface drip irrigation system and water-conducting device arranged in the soil under the dripper. Water-conducting device includes upper impermeable boundary, lower permeable boundary and permeable base impermeable boundary is generally the PVC tube[3,4]. The tube and the space within a certain depth downward to the tube bottom are filled with coarse sand, leading to the formation of cylinder sand column under the tube bottom. The sand column surface and the bottom surface under the sand column are taken as lower permeable boundary and permeable base, respectively. Water infiltrates through permeable boundary and permeable base into the surrounding soil. Experimental results showed that ISDI could reduce soil evaporation and increase water use efficiency compared with surface drip irrigation[2,5,6]. Xie *et al.*[7] studies the effects of different lower limits of water supply on the characteristics, quality and yield of melon plants under ISDI condition with conventional furrow irrigation as the contrast. Sun *et al.*[8] study the influence of irrigation amount under ISDI and ordinary surface drip irrigation on the fruit growth and quality of jujube. However, similar to surface drip irrigation, ISDI belongs to local irrigation with limited soil wetting pattern. The size and distribution of soil wetting pattern can affect the crop yield, it's seriously affected by drip discharge[9-11]. Thus, drip discharge is one of the most important elements of irrigation technology in local irrigation design which not only directly affects on fruit growth and quality but also has a direct effect on water use efficiency. Therefore, the effects of drip discharge on water distribution in the root zone of jujube, fruit growth and quality and water use efficiency under ISDI were studied and theoretical basis was provided for the application of ISDI in fruit irrigation in the arid areas.

MATERIALS AND METHODS

Test conditions: The test was done in College of Water Conservation and Architectural Engineering of Tarim University in Alar city, Xinjiang province from May-September, 2012. The shape of the tested soil was shown in Table 1. The trees were 4 years grafted seedlings with wild jujube as the understock and Xinjiang jujube as the grafting variety. They grew well and uniformly without severe diseases. Drip fertigation was adopted here.

Design of experiment: The experiment was designed to use two drip irrigation methods: For ISDI, there were three discharge levels being 2 $m^3\ h^{-1}$ (T_1), 3 $m^3\ h^{-1}$ (T_2) and 4 L h^{-1} (T_3), respectively. For surface drip irrigation, it was as a contrast, the discharge was 3 $m^3\ h^{-1}$ (CK). There were a total of 4 experiment plots, 6 trees in each. Three trees in each plot were selected to measure the indexes of crops during the growth period, as a repeat. The single irrigation amount was the same for each treatment being 14 L per tree. The irrigation systems of different treatments were the same, as shown in Table 2.

Planting pattern and fertilization: Six jujube trees which were arranged in a straight line with the plant spacing of 1 m were selected as a test plot. In the plot implanting ISDI, 1 water-conducting device was set for each tree. It was put on the line connecting trunks, 200 mm far from the trunk horizontally. The drip irrigation pipe (pipe diameter 16 mm and wall thickness 0.9 mm) was 100 mm far from the trunk, one pipe for one line. Jujube tree planting and water conducting device arrangement were shown in Fig. 1.

Table 1: Physical and chemical properties of the experimental soil

Soil depth (cm)	Soil texture	Saturated water content (%)	Field water retaining capacity (%)	Soil bulk density (g cm^{-3})	pH value	Salinity content (%)
0-10	Sandy loam	28.37	19.43	1.38	8.18	0.19
10-20	Sandy loam	28.39	19.18	1.39	8.19	0.17
20-30	Sandy loam	27.68	19.22	1.40	8.25	0.14
30-40	Clay interlayer	30.46	26.43	1.43	8.43	0.15
40-50	Sandy soil	27.87	24.15	1.42	8.24	0.13

Micro sand filter for drip irrigation system and micro fertilizer tank were installed in the test plots. Drip-irrigation fertilizer special for jujube was adopted with the standard of 75 kg h m^{-2} each time, a total of 6 times in the whole growth period. Base fertilizer was fertilized in spring. Other agricultural management measures were the same as those for general field jujube gardens. Auxiliary pipes and capillaries were laid on the surface. One capillary controlled one test plot. The valve and water meter on each capillary controlled the irrigation amount of the plot separately.

Water-conducting device components and installation: Components are shown[4] in Fig. 2 and they include the drip irrigation pipe, small pipe, adjusting valve, water-conducting device, coarse sand filling inside the water-conducting device, impermeable boundary (PVC pipe), permeable boundary (coarse sand) and permeable bottom (coarse sand). The first step of the installation is to drill a 25 cm deep hole in the soil with a diameter slightly greater than that of the water-conducting device to be deployed. Sand is passed through a 2-5 mm sieve and then wrapped in a nylon net with a thickness of 15 cm. The net is placed at the bottom of the 30 cm PVC pipe and then inserted into the bottom of the soil hole. Finally, the soil is tamped down and the PVC pipe is withdrawn by 5 cm to create a 5 cm thick permeable boundary. The small pipe is installed on the drip irrigation pipe

Table 2: Irrigation schedul

	Irrigation quota (Liter per plant)						
Treatment	Bud and leaf stage 4-10~5-21	Flowering period 5-22~6-26	Initial fruit period 6-27~7-18	Fruit expanding stage 7-19~8-25	Initial maturity stage 8-26~9-05	Late fruit maturity stage 9-06~10-15	Irrigation quota (Liter per plant)
CK, T_1, T_2, T_3	14	28	28	56	14	14	154

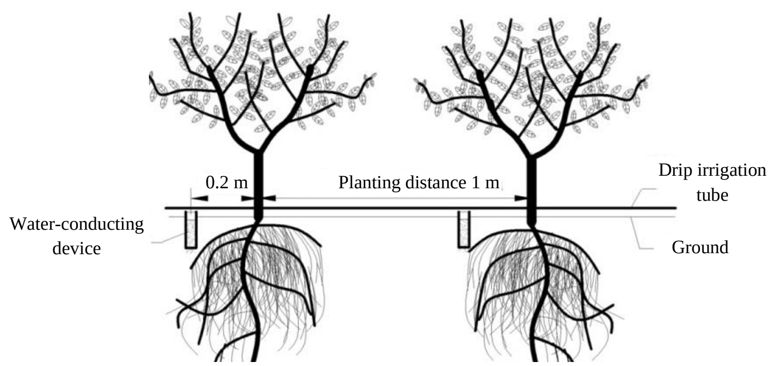

Fig. 1: Diagram of the jujube planting pattern and water-conducting device

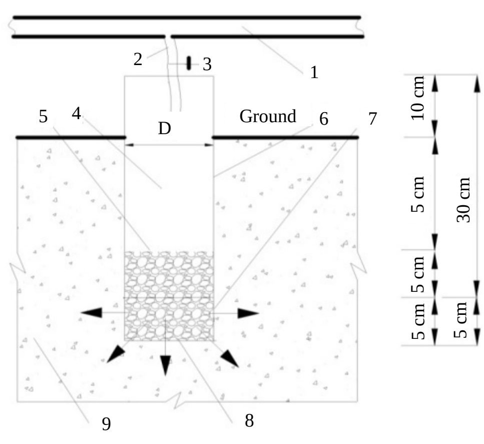

Fig. 2: Diagram of the ISDI components and irrigation principles, 1: Drip irrigation pipe, 2: Small pipe, 3: Regulating valve, 4: Water-conducting device, 5: Coarse sand, 6: Impermeable boundary of the water-conducting device, 7: Permeable boundary of the water-conducting device, 8: permeable bottom and 9: Root zone soil

above the water-conducting device to introduce water into the water-conducting device. The small pipe contains the regulating valve for flow control.

Observation items and method

Soil moisture content: Sampling time: before irrigation and 24 h after irrigation. Sampling position: with the water-conducting device as the center, collecting soil at the profiles 10, 20 and 30 cm away from the water-conducting device horizontally in the direction perpendicular to the radial direction of drip irrigation pipe (called A, B and C profiles), respectively. The soil collection depths were 0-10, 10-20, 20-30, 30-40 and 40-50 cm for the profiles. Three trees were selected randomly in each plot for soil collection at the same time. The repeated soil samples were mixed thoroughly and brought back to the lab for test and analysis. Soil moisture content was determined by the drying method.

Grow characteristics of jujube

Plant height determination: Measuring the plant height with the tape once every 10 days (from the root of the plant to the highest point of the top of upper leaves on the trunk), measurement precision: 0.1 cm. Plant diameter determination: marking the location with a marker pen and measuring the diameter with the vernier caliper once every 10 days, measurement precision: 0.2 mm. New tip length determination: Selecting the representative new branch to tie a red ribbon, marking the location with a marker pen and measuring the new tip length with a flexible rule once every 10 days (from the intersection point of new branch and the trunk to the highest point of the blade), measurement precision: 0.1 cm.

Fruit yield and quality: After jujubes were harvested, 20 fruits were selected immediately and then dried to measure the following indexes: Total sugar content: Using Fehling's solution method, Vc content: Using dechloro-indophenol titration method[12], soluble protein content: Using Kaumas brilliant blue colorimetric method, organic acids: Using acid-base titration method[13], fruit weight: Using the weighing method with the precision of 0.01 g. Vertical and transverse diameters were measured with vernier caliper.

The yield of each plot was calculated. After the fruits were mature and dried naturally, the yields of 6 trees in each treatment were weighed separately. The yield of each tree in each treatment was obtained by summing the yields of 6 trees and then averaging. Finally, the yield per unit area was obtained according to the number of jujube trees per unit area.

Water use efficiency:

$$WP_i = Y/W_i \quad (1)$$

where, WP_i was the use efficiency of irrigation water (kg m^{-3}), Y was the total crop yield or average yield (kg or kg h m^{-2}) and W_i was the total irrigation water or irrigation water amount per unit area (m^3 or m^3 h m^{-2}).

Statistical method: Excel was used for the data processing and variance analyses and the significance level is 5%.

RESULTS

Effect of dripper discharge on the soil moisture distribution in the root area of jujube: In the study, ISDI the water-conducting device was buried 20 cm deep. Water seeped into the soil from the permeable boundary 20-25 cm below the surface. When the water close to the permeable boundary was saturated, it spread around from the vertical and horizontal directions, forming the ellipsoid-like wetted volume with the outlet as the center. Figure 3 showed the moisture distribution in the root area of jujube after single irrigation. According to the figure, the soil moisture content in the 20-30 cm soil layer in the vertical direction was the highest. With the increase of the distance to the outlet, the moisture contents of the soil layers in the vertical direction gradually reduced upward and downward, so were those in the horizontal direction.

Under surface drip irrigation, point-source water entered the soil at the ground surface. Dripped water resulted in nearly saturated soil water content under the dripper and then water slowly diffused to form a semicircular cone-like wetted body under the dripper[14]. Figure 3 (treatments CK) shows that the surface soil water content is the highest along the vertical direction and that the soil water content gradually declines with increase of soil depth. Along the horizontal direction, the soil water content also gradually declined with increase of distance to the dripper.

At the same time, Fig. 3 showed that the dripper discharge had significant influence on the shape and size of the wetted soil volume. When the discharge was small, the maximum wetted distance in the vertical direction was significantly greater than that in the horizontal direction. With the increase of the discharge, the maximum wetted distance in the vertical direction gradually reduced and that in the horizontal direction gradually increased. Under the same irrigation amount for three treatments, the soil moisture content close to the outlet increased with the increase of the

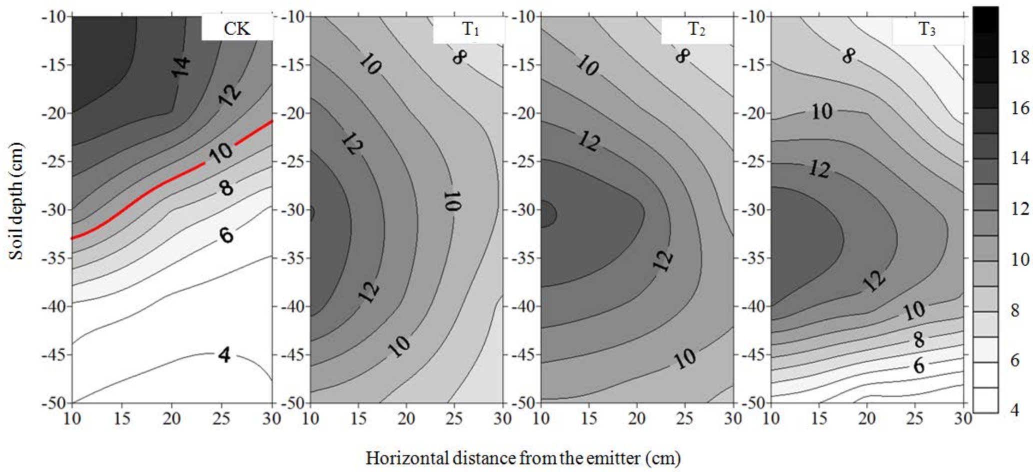

Fig. 3: Effects of dripper discharge on the moisture distribution in the root area of jujube (%)

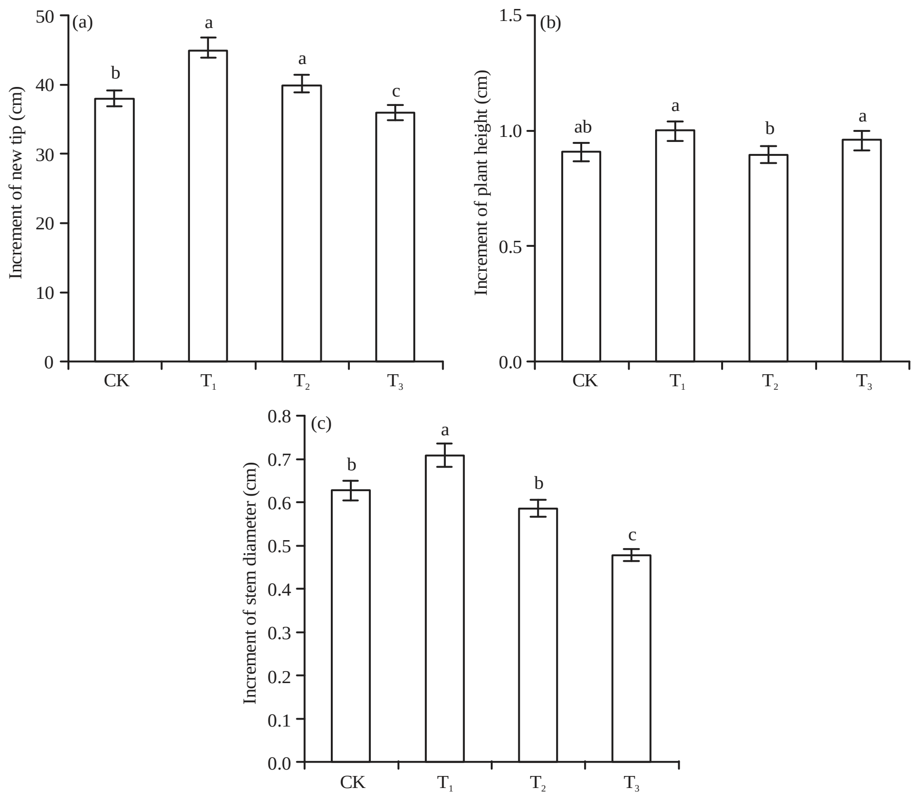

Fig. 4(a-c): Effect of different treatments on growth of the influence of jujube per centimeter, values followed by different letters in the same column are significantly different at $p<0.05$

dripper discharge. Finally, the wetted volume formed by the large dripper discharge was small, which was consistent with the previous research results[15,16].

Effect of dripper discharge on the plant growth of jujube: Plant height, length of new tip and stem diameter are important physiological indexed characterizing the plant growth rate. Figure 4 showed the increments of new tip, plant height and stem diameter of jujube under different treatments from June 10-September 20. According to the Fig. 4a, the dripper discharge had no significant influence on the increment of new tip of jujube. In general, plant height and stem diameter increased slowly under different treatments. The T_1 had the maximum plant height increment of 1.2 cm and the maximum stem diameter increment of 0.71 cm. The increments of both plant height and stem diameter tended to reduce with the increase of the dripper discharge, indicating that the small discharge was conductive to the trunk growth of jujube (Fig. 4b, c).

Effect of dripper discharge on the fruit size of jujube: The effects of different dripper discharges on the longitudinal and traverse diameters of jujube fruit were shown in Fig. 5. Under T_1, the longitudinal and traverse diameters of fruit were the largest, being 43.3 and 30.1 mm, respectively. With the increase of the dripper discharge, the longitudinal and traverse diameters of fruit tended to reduce with the increase of the dripper discharge. The longitudinal and traverse diameters of fruit under T_3 were significantly smaller than those of T_1, T_2 and T_1, T_2 had no significant difference in this aspect, indicating that small discharge was conductive to fruit growth. The dripper discharge had no significant influence on the fruit shape index. It may be because that the fruit shape index of jujube was basically constant which had little change with the fruit size.

Effect of different dripper discharges on the fruit quality of jujube: Single fruit quality is one of the important qualities affecting the fruit quality. It could be seen from Fig. 6a that the single fruit quality of T_2 treatment was the largest, being 18.01 g but it had no significant difference from T_1. The single fruit quality of T_3 was significantly smaller than that of T_1 and T_2, indicating that large discharge was not conductive to the fruit growth of jujube. It could also be seen from Fig. 6a, different irrigation methods had significant effect on jujube fruit weight, when the discharge was the same the jujube

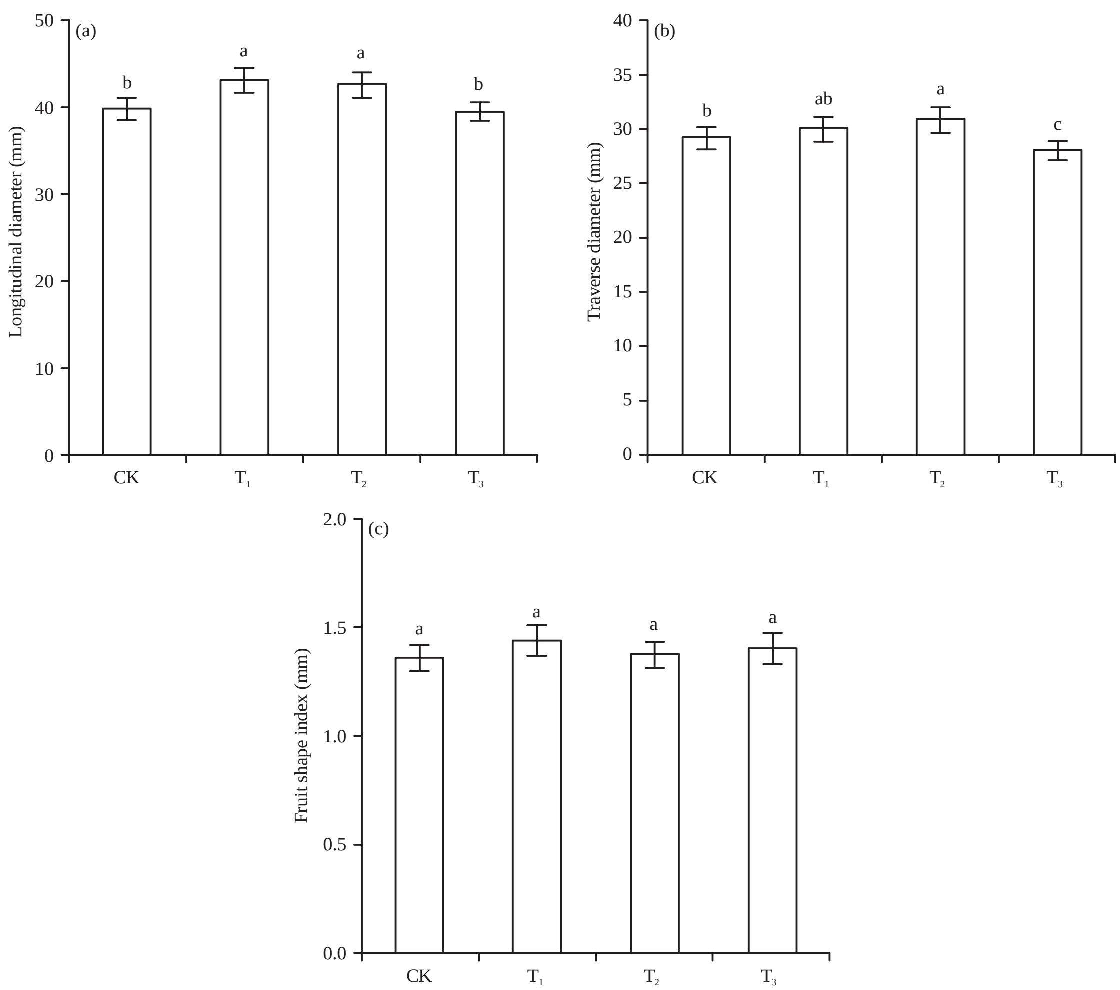

Fig. 5(a-c): Effect of different treatments on growth of jujube, values followed by different letters in the same column are significantly different at $p<0.05$

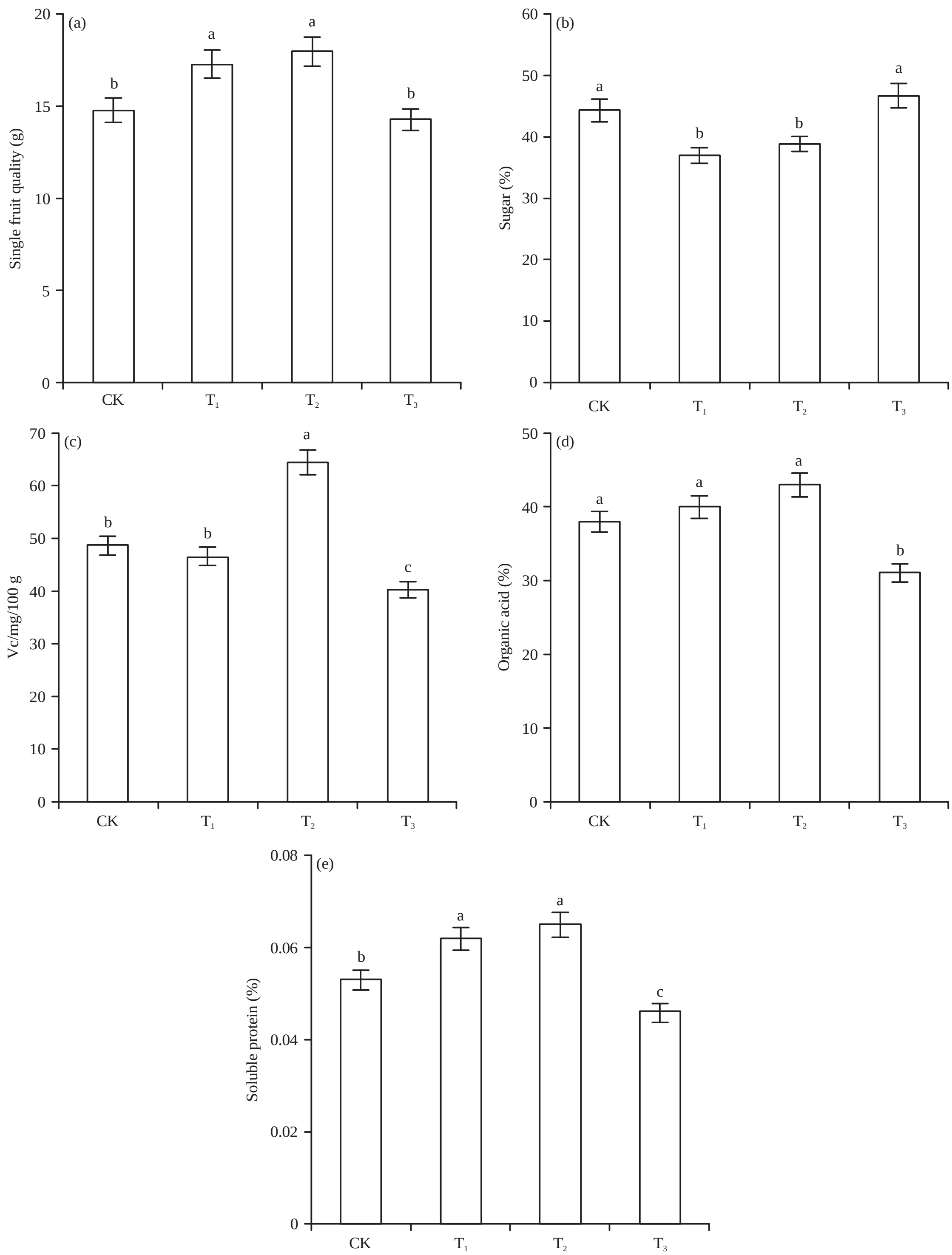

Fig. 6(a-e): Effect of different treatments on fruit quality, values followed by different letters in the same column are significantly different at p<0.05

weight is 14.8 g under CK treatment (Surface drip irrigation), the jujube weight is 18.01 g under T_2 treatment (ISDI), increased by 22%.

Soluble sugar content in jujube is an important indicator which directly affects the fruit quality. At the same time, it also directly affects the fruit flavor. Therefore, it could be seen from

Table 3: Effect of different discharges on the yield of jujube and water use efficiency

Treatment	Yield (kg h m^{-2})	Irrigation amount (m^3 h m^{-2})	Water use efficiency (kg m^{-3})
CK	2387^c	770	3.1^c
T_1	2653^a	770	3.44^a
T_2	2495^b	770	3.24^b
T_3	2322^c	770	3.02^c

Values followed by different letters in the same column are significantly different at p<0.05

Fig. 6b that the total sugar content in fruit tended to reduce with the increase of the dripper discharge. The sugar content of fruit of T_1 was the highest being 46.62%, significantly higher than that of T_2 and T_3, indicating that small discharge was conductive to increasing the sugar content of fruit.

Vitamin C, also known as ascorbic acid, belongs to small molecule. It's one of the important indicators measuring the aging degree of fruits and vegetables. Jujube contains rich vitamin C. It could be seen from Fig. 6c that the fruit in T_2 contained the highest VC, being 64.32 mg/100 g. Soluble protein content reflects the nitrogen metabolism and viability of jujube fruit. It's also an important indicator reflecting the metabolic ability of photosynthesis products. It could be seen from the contents of organic acid and soluble protein (Fig. 6d, e) that the contents of organic acid and soluble protein in fruit were highest in T_2, being 0.43 and 0.065%, respectively but the difference between T_2 and T_2 is not significant. The contents of organic acid and soluble protein in fruit in T_2 and T_1 were significantly higher than those in T_3, indicating that small discharge could increase the contents of organic acid and soluble protein.

Effect of different dripper discharge on the yield of jujube and water use efficiency: It could be seen from Table 3 that the yield of jujube was highest in T_1 being 2653 kg (kg hm^{-2}), followed by T_2 and T_3. Water use efficiency was also highest in T_1, being 3.44 kg m^{-3}, which meant irrigating 1 m^3 of water could produce 3.44 kg fruits. The value increased by 14.29% compared with that of T_3. The results further showed that small dripper discharge was conductive to promoting the fruit growth of jujube, increasing the yield and further improving Water use efficiency.

The yield of jujube was significantly higher by ISDI (T_2) than that by surface drip irrigation (CK), It improved the utilization of jujube water compared with T2 treatment also with the same discharge.

DISCUSSION

The soil wetted volume reduced and average moisture content increase with dripper discharge increase under same irrigation amount[16]. The distribution range of the crop root was narrow and deep with small dripper discharge, however, under it was wide and shallow with bigger dripper discharge[15,17-19]. Yohannes and Todesse[18] and Wang *et al.*[19] studied that effects of dripper discharge on growth, Yield and quality of cucumber and tomato, which showed that there was no significant effect on growth, yield and quality of the vegetables. The study showed that leaf chlorophyll mean content of dripper discharge q = 2.00 L h^{-1} in jujube was higher than the big dripper discharge q = 3.75 L h^{-1} treatment for 4.2%, which illustrated with small dripper discharge could increase the chlorophyll content of leaves[20]. All of these results indicate that the change of dripper discharge had a certain effect on the crops and these results are consistent with the results of this study.

The study reflected that large dripper discharge could increase the maximum wetted distance in the horizontal direction and small dripper discharge could increase the maximum wetted distance in the vertical and downward direction[16]. The results of this study the maximum wetted distance in the vertical direction gradually reduced and that in the horizontal direction gradually increased with the increase of the dripper discharge and small dripper discharge could promote the growth of jujube, improve fruit quality and improve crop yield and water use efficiency, which may be because the wetted volume formed by small dripper discharge could promote the root development of jujube downward.

CONCLUSION

The maximum wetted distance in the vertical direction gradually reduced and that in the horizontal direction gradually increased with the increase of the dripper discharge. The soil moisture content near the outlet increased with dripper discharge and the formed soil wetted volume gradually reduced.

The sugar content of fruit of T_1 was the highest: being 46.62%, significantly higher than that of T_2 and T_3, indicating that small discharge was conductive to increasing the sugar content of fruit. The contents of organic acid and soluble protein in fruit in T_2 and T_1 were significantly higher than those in T_3, indicating that small discharge could increase the contents of organic acid and soluble protein.

The T_1 had the highest yield of jujube (2653 kg h m^{-2}) and the highest Water use efficiency (3.44 kg m^{-3}), being 3.44 kg m^{-3}, which meant irrigating 1 m^3 of water could produce 3.44 kg fruits. The value increased by 14.29% compared with that of T_3.

Small dripper discharge was conductive to promoting the growth of jujube, improving the fruit quality and increasing the yield of jujube and water use efficiency.

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REFERENCES

1. Very, A.A. and H. Sentenac, 2003. Molecular mechanisms and regulation of K^+ transport in higher plants. Ann. Rev. Plant Biol., 54: 575-603.
2. Meshkat, M.R.C., 1997. Modeling and laboratory evaluation of evaporation and moisture redistribution for drip/trickle and sand tube irrigation using undisturbed and reconstructed soils. Ph.D. Thesis, University of Kentucky, Lexington, KY.
3. Zhao, W.X., Z.H. Zhang and H.J. Cai, 2009. Parameter model of water-conducting device specification for indirect subsurface drip irrigation. J. Hydraulic Eng., 40: 355-363.
4. Sun, S.M., Q.X. An, H.J. Cai, B.L. Yao and Y. Qiao, 2015. Research on salt movement law in jujube root zone under indirect subsurface drip irrigation. Trans. Chin. Soc. Agric. Machin., 46: 160-169.
5. Meshkat, M., R.C. Warner and S.R. Workman, 1998. Comparison of water and temperature distribution profiles under sand tube irrigation. Trans. Chinese Soc. Agric. Eng., 41: 1657-1663.
6. Yanni, S., M.N. Nimah and I. Bashour, 2004. Gravel vertical mulching for improving water use efficiency of drip irrigated orchards. Acta Hortic., 664: 673-681.
7. Xie, H.X., H.J. Cai and Z.H. Zhang, 2010. Effects of indirect subsurface irrigation on plant physiological characteristics, quality and yield of greenhouse Muskmelon. J. Irrigation Drainage, 29: 50-52.
8. Sun, S.M., Q.X. An and H.C. Ye, 2014. Effects of different irrigation methods on growth and quality of jujube. J. Irrigation Drainage, 33: 122-124.
9. Li, G.Y., D.C. Zeng and Y.Q. Zheng, 1998. The mathematical model of water movement from a surface trickle source. J. Hydraulic Eng., 11: 21-24.
10. Wang, Z.R., W.Y. Wang, Q.J. Wang and J.F. Zhang, 2000. Experimental study on soil water movement from a point source. J. Hydraulic Eng., 6: 39-44, (In Chinese).
11. Li, M.S., S.Z. Kang and H.Y. Sun, 2006. Relationships between dripper discharge and soil wetting pattern for drip irrigation. Trans. Chinese Soc. Agric. Eng., 22: 32-35.
12. Li, H.S., 2004. Principle and Technology Experiments of Plant Physiological and Biochemical. Higher Education Press, Beijing, pp: 195-197.
13. Xiao, L.T. and S.G. Wang, 2005. Experiment Technology of Plant Physiology. China Agriculture Press, Beijing, pp: 211-212.
14. Zhang, W., X. Lu, L.H. Li, J.G. Liu, Z.J. Sun, X.W. Zhang and Z.P. Yang, 2008. Salt transfer law for cotton field with drip irrigation under the plastic mulch in Xinjiang Region. Trans. Chinese Soc. Agric. Eng., 8: 15-19.
15. Sun, H., M. Li, H. Ding, Y. Wang and W.M. Cui, 2009. Experiments on effect of dripper discharge on cotton-root distribution. Trans. Chinese Soc. Agric. Eng., 11: 13-18.
16. Zhao, Y.N., Y.K. Wang, L.H. Ma, P.H. Li, X.S. Duan and L.J. Zhang, 2010. Study on effects of different dripper discharge on wetting soil characteristic of drip irrigation. Agric. Res. Arid Areas, 28: 30-34.
17. Wang, X.K., Y.N. Li, Y.Y. Xing and Y. Huang, 2010. Effect of dripper discharge on summer maize-root distribution. China Rural Water Hydropower, 11: 66-68.
18. Yohannes, F. and T. Tadesse, 1998. Effect of drip and furrow irrigation and plant spacing on yield of tomato at Dire Dawa, Ethiopia. Agric. Water Manage., 35: 201-207.
19. Wang, S., G.Y. Li, G.X. Meng, Y.M. Jia, Z.H.Wang, J.Q. Qiu and S.Q. Duan, 2005. Effects of dripper discharge and spacing on growth of cucumber in Chinese solar greenhouse under drip irrigation. Trans. Chinese Soc. Agric. Eng., 21: 167-170.
20. Wang, J., L. You and B. Zheng, 2015. Effect of different water dropper flow on red jujube physiological indexes. Modern Agric. Sci. Technol., 17: 83-85.