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Effects of Irrigation Method on the Growth and Yield of Eggplant

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Abstract

Field experiments were conducted at an experimental station of Northwest A&F University, Institute of Soil and Water Conservation in China during 2016. The experiment comprised planting eggplant in three irrigation methods, namely, conventional irrigation, fixed irrigation and alternate irrigation. The study indicated that the effect of different irrigation method on growth of eggplant was different in different growth stages. Roots activity of eggplant in the flourishing fruit stage was the greatest, followed by the seedling stage. In three growth stage, roots activity for alternate irrigation was the greatest in all treatments. The early, middle and late yield of alternate irrigation were greater than that of conventional irrigation and fixed irrigation, the early and middle yield of eggplant with fixed irrigation was greater than that of conventional irrigation, the late yield was smaller than that of conventional irrigation, the total yield of alternate irrigation in eggplant was the highest in all treatments, for 66.59 kg, which were higher than that of conventional irrigation and fixed irrigation, for 14.11% and 27.16%. The water use efficiency and water productivity of eggplant for alternate irrigation were 37.16 kg hm^{-2} mm^{-1} and 29.81 kg hm^{-2} mm^{-1}, which was higher than that of fixed irrigation and conventional irrigation, 22.11%、27.50% and 117.31%, 128.78%, respectively.

Keyword: Eggplant; Irrigation method; Roots activity; Yield

Introduction

The origin of eggplant is India, Thailand, the eastern han dynasty was introduced into China. Eggplant is distributed all over the world, with the most cultivated plant in Asia, accounting for about 74% of the world's total production, Europe is second, at around 14%. Eggplant is grown in north and south China. Eggplant (*Solanum melongena* L.) is belongs to the Solanaceae family of plants.

Eggplant is a remunerative crop in northern Chinese. Soil water is an importance environment factor of crop development. Vegetable is a high yield crop and succulent crop and needs more water. Therefore, management of soil water is the technique key of high yield culture in vegetable. Eggplant is considered as one of the important commercial vegetable crops grown in greenhouse in winter and springtime of China northern. More studies have been done on irrigation of crops [1-7]. There are more reports on translocation and allocation of carbohydrate and yield in rice [8-12], in maize [13-16], in wheat [17]. Irrigation method of high technique such as spray irrigation, seep irrigation, and trickle irrigation was studied on vegetables [18-21] and fruit tree [22,23]. But some problem in application existed in these irrigation method, and high investment, therefore it's were limited in generalization and application. At present, major irrigation method in production was conventional irrigation method. Aim of experiment was at studying of conventional irrigation, fixed irrigation and alternate irrigation on growth development, yield, and water use efficiency and water productivity of eggplant, in order to provide a guideline to regional growers and irrigation agencies for irrigation water savings and optimum water management programs for eggplant in the north-west region of China.

Material and Method

Experimental site and soil conditions

Field experiments were carried out in the greenhouse in the Northwest A&F University, Institute of Soil and Water Conservation, yangling, shaanxi People's Republic of China China at 2016 (Figure 1). The greenhouse was 70 m long in east-west orientation, 3.5 m in ridge height, 7.0 m in span and unheated. The soil of the experimental site is dark loessial soil in texture, the soil properties in the top 20 cm are as follows: bulk density, 1.30 g cm^{-3}; organic matter content, 10.68 g kg^{-1}; the field water capacity, 24%; total nitrogen, 0.82 g kg^{-1}; total phosphorus, 0.54 g kg^{-1} ; total potassium, 15.50 g kg^{-1}; available N, 49.98 mg kg^{-1}; available phosphorus content, 21.45 mg kg^{-1}; available potassium content, 155.69 mg kg^{-1}.

Experimental design and treatments

Treatments consisted of three irrigation methods, conventional irrigation (each row was irrigated), fixed irrigation (each time irrigated the same row) and alternate irrigation (each time irrigated the different row). Plastic film (depth 1 m) was placed between plots in order to prevent penetration of soil water in different experiment plots (Figure 2).

The experimental design was in random blocks with three repetitions for each of three water treatments tested. The treatments devised according to eggplant's water requirement disciplinarian. The amount of irrigated water was used to control with water meters.

Water treatments were treated on 7 day after transplanting, interval period was 4-7 days, and terminated on July 23th 2016.

Crop agronomy

Eggplant (*Solanum melongena* L. Xi'an Green eggplant) seeds were sown in nutritional bowl (10 cm in diameter, 15 cm in height) on January 7th in 2016, respectively. The eggplant seedling was transplanted on April 15th to experimental plots (5.6 m long, 2.4 m wide) when the plants appeared the fourth genuine leaf. Row spacing was 60 cm, plants spacing was 32 cm. Other managements were similar to normal cultivation in greenhouse. Greenhouse was unheated, ventilate as much

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Figure 1: Geographic position of the study area.

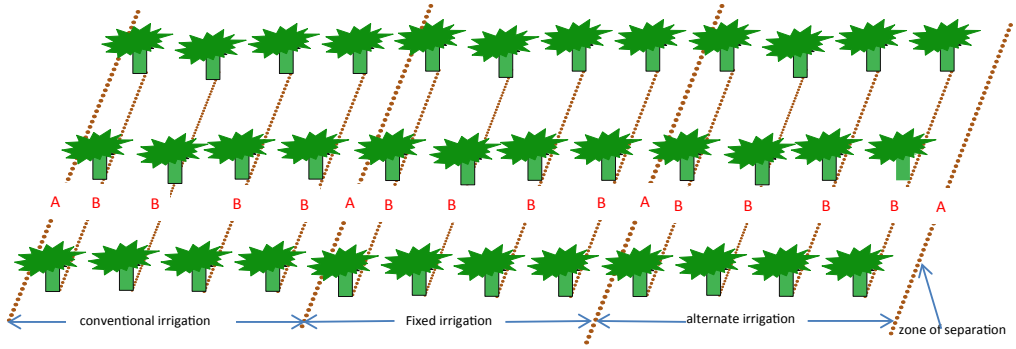


Figure 2: Layout design of experimental design
Note: A and B are on the same horizontal line. Distance of A and B, and B and A is 30 cm, Distance of B and B is 60 cm, Distance of plants is 32 cm

as possible to completely air out the room air, plastic film was ordinary plastic sheeting and used to keep out rain.

Method

Plant height, leaf number, leaf area, at each experimental plot were measured at the period of experiment (April 20: before water treatment, May 19: initial flowering stage, June 21: flourishing fruit stage, July 16: before the harvest). Aboveground biomass and root biomass at each experimental plot were measured at the end of experiment. Root activity was measured at seedling stage, flourishing fruit stage and harvest stage of eggplant growth with TTC [24]. Total biomass consisted of the total fruit weight and the other plant weight. Other items were measured by conventional method. Eggplant yield was measured every other day.

Statistical analysis

Experimental data were analyzed using Excel 2003 (Microsoft Inc) and ANOVA in SAS for Windows. Duncan's multiple range test ($P<0.05$, 0.01) was conducted to determine the significance of differences between means.

Results

Eggplant growth

The growth and development of the eggplant varied under different irrigation methods in different stage (Table 1). At growth prophase, eggplant height of fixed irrigation was the highest in three treatments, followed by alternate irrigation, leaf numbers and leaf area of alternate irrigation was the biggest, followed by fixed irrigation, as the soil and air temperature was lower, the temperature was limited factor for the growth and development of eggplant, irrigation amount and irrigated area of conventional irrigation was bigger than that of alternate

Treatments		Conventional Irrigation	Fixed Irrigation	Alternate Irrigation
Plant height(cm)	April 20	13.9	14.0	14.1
	May 19	24.7	29.9	29.6
	June 21	68.8	61.9	67.1
	July 16	88.0	82.5	80.1
Leaf number	April 20	7.3	7.4	7.3
	May 19	10.5	11.2	11.4
	June 21	18.5	20.1	22.8
	July 16	23.7	26.0	29.4
Leaf area(cm^2)	April 20	98.18	97.98	98.06
	May 19	178.49	220.99	247.89
	June 21	343.32	333.98	340.90
	July 16	326.58	317.76	323.32

Table 1: Effect of different irrigation method on growth of eggplant.

irrigation and fixed irrigation, affecting the eggplant surrounding soil temperature increased, thus affecting the growth and development of the eggplant. With the growing process of conversion and air temperature continued to rise, conventional irrigation the eggplant plant height and leaf area increased rapidly, and reached to maximum, for 88 cm and 326.58 cm^2 at harvest stage, followed by fixed irrigation, eggplant leaf numbers of alternate irrigation was more than that of fixed irrigation, and fixed irrigation was more than that of conventional irrigation. As temperature was not limited factor for the growth and development of eggplant at this moment, because of the soil and air temperature continuing rise and sufficient irrigation, led to eggplant plants excessive growth in conventional irrigation, affected eggplant leaves number increasing as well (Table 1).

Roots activity

Plant root system is active absorption and synthesize organ, the growth status and activity of roots affects straightly on nutrition status and yield of crop.

In seedling stage, eggplant root activity of alternate irrigation, conventional irrigation and fixed irrigation were 195.6、152.4、174.2 ug $g^{-1}h^{-1}$, respectively, and alternate irrigation was higher than that of conventional irrigation and fixed irrigation, for 28.35% and 12.27%, fixed irrigation was higher than that of conventional irrigation, for 14.30%. At flourishing fruit stage, eggplant root activity of alternate irrigation was 264.3 ug $g^{-1}h^{-1}$, conventional irrigation was 230.9 ug $g^{-1}h^{-1}$, and fixed irrigation was 211.5 ug $g^{-1}h^{-1}$. At harvest stage, in terms of root activity, were ranked in the descendant order of alternate irrigation, conventional irrigation and fixed irrigation, alternate irrigation was higher than that of conventional irrigation by 16.75%, conventional irrigation was higher than that of fixed irrigation by 5.02%. There was remarkable difference or significantly difference among three treatments (P<0.05, 0.01) (Figure 3).

Yield

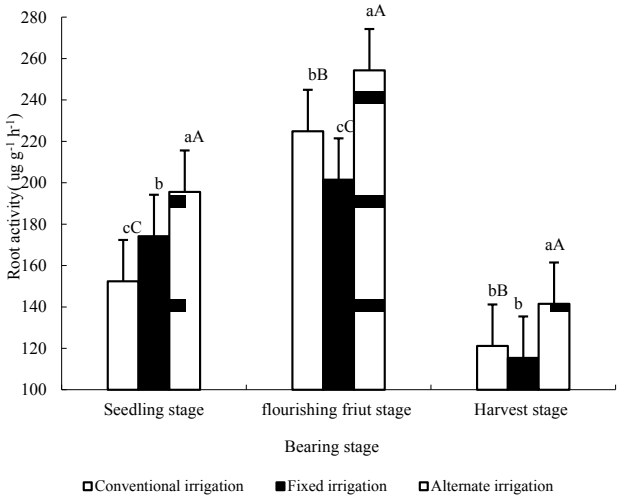
Total yield of alternate irrigation, conventional irrigation and fixed irrigation were 66.59 kg, 58.35 kg, 52.36 kg, respectively. Increased yield of alternate irrigation was 14.11% and 27.16% than that of conventional irrigation and fixed irrigation, conventional irrigation was more than that of fixed irrigation, for 11.43%, there were remarkable differences between three irrigation method (P<0.05, 0.01).

Early yield, middle yield and later yield of alternate irrigation was the highest in all treatment, which were higher than that of conventional irrigation and fixed irrigation, for 35.59%, 22.13%, 8.55%, 14.11%, and 23.54%, 119.76%, Early yield of fixed irrigation was higher than that of conventional irrigation, for 11.02%, middle yield, later yield of conventional irrigation was higher than that of fixed irrigation, for 5.15%, 82.31%.

Fruit numbers of alternate irrigation was more than that of fixed irrigation and conventional irrigation (Figure 4).

Water Use Efficiency and Water Productivity

Water consumption amount was analyzed by evapotranspiration in growth period of eggplant. In three treatments, in terms of biomass and yield, were ranked in the descendant order of alternate irrigation, conventional irrigation and fixed irrigation. But, in terms of water consumption amount, were ranked in the descendant order of conventional irrigation, fixed irrigation, and alternate irrigation. Water use efficiency and water productivity of alternate irrigation was the highest in treatments, for 37.16 kg hm^{-2} mm^{-1} and 29.81 kg hm^{-2} mm^{-1}, which were 22.11%, 27.50% and 117.31%, 128.78% higher than that of fixed irrigation and conventional irrigation, respectively, fixed irrigation was higher than that of conventional irrigation, for 77.95% and 79.43% (Table 2), there were extremely significant differences in



Note:Different lowercase letters meant significant difference among treatments at 0.05 level. Different capital letters meant difference among treatments at 0.01 level. The same below

Figure 3: Root activity of different treatments in eggplant.

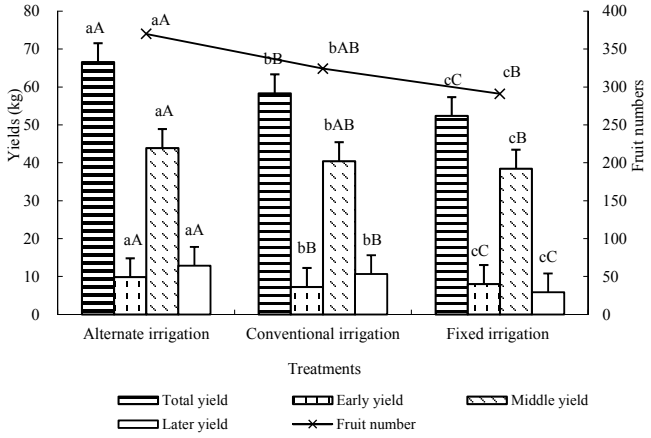


Figure 4: Effects of different irrigation style on yield consitutetion of eggplant

Treatments	Conventional Irrigation	Fixed Irrigation	Alternate Irrigation
Biomass(kg hm^{-2})	57010.91bAB	50723.64cB	61776.36aA
Yield(kg hm^{-2})	43418.18bB	38963.64cB	49545.45aA
Water consumption amount (mm)	3333.33aA	1666.67bB	1662.32bB
Water use efficiency(kg hm^{-2} mm^{-1})	17.10cC	30.43bB	37.16aA
water productivity (kg hm^{-2} mm^{-1})	13.03cC	23.38bB	29.81aA

Note: Different lowercase letters after number in the same row meant significant difference among treatments at 0.05 level. Different capital letters after number in the same row meant difference among treatments at 0.01 level.

Table 2: The water consumption amount, water use efficiency of eggplant and in different treatments.

water use efficiency and water productivity among three treatments ($p<0.01$).

Discussion

Irrigation methods had certain impact on the growth of eggplant. In growth initial stage of eggplant, plant height for fixed irrigation was highest in treatments, alternate irrigation was second, leaf areas of alternate irrigation was highest in treatments, fixed irrigation was second. In development metaphase and anaphase, plant height and leaf areas of conventional irrigation were highest in three treatments; plant height of fixed irrigation was second, alternate irrigation of leaf areas was second. But in whole development stage, eggplant yield and water use efficiency of alternate irrigation was highest in three treatments, eggplant yield of conventional irrigation was second, water use efficiency of fixed irrigation was second.

Alternate irrigation could compel the part root zone temporary mild water stress, produced ABA and transported to leaves and adjusted stomata aperture, reduced transpiration rate when drought and wetness appeared by turns in different region of root. On the other hand, alternate irrigation was in favor of accelerating roots uniform growth and distribution by alternating wet and dry, increased root and soil contact area, enhanced root activity, helped to absorb nutrition and water of soil, thereby it improved water and nutrition use efficiency and increased eggplant yield. Fixed irrigation was only irrigated planting row, long-term water stress of soil in non-irrigation row, it affected equality distributing of root of soil in some extent, and was not favor of absorbing and utilization of nutrient of soil in non-irrigation zone. Irrigation amount of conventional irrigation was so much that planting row and working row was usually waterish, soil character become bad, reduced absorbency of root system, and affected on soil water and nutrient absorbing and utilization.

Conclusion

Planting vegetable at early spring in greenhouse, soil water management should be different in different stage. This study showed that eggplant root activity of alternate irrigation was higher than that of conventional irrigation and fixed irrigation in bearing stage; the eggplant yield, biomass, WUE, and water output rate of alternate irrigation were the highest in three irrigation methods; the eggplant yield and biomass of conventional irrigation was higher than that of fixed irrigation; WUE, and water output rate of fixed irrigation was higher than that of conventional irrigation.

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