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Original Research Paper

Experimental Study on Water Use Efficiency of Winter Wheat in Different Irrigation Methods

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ABSTRACT

In order to probe dry matter accumulation, grain yield and water use efficiency of winter wheat, the study has been conducted under three irrigation treatments by the different irrigation methods. The results show that winter wheat water consumption and the ground dry matter accumulation gradually increase under the different irrigation conditions, with the increase in the number of irrigations, while yield and water use efficiency increase at first and then decrease. Under the same irrigation times, the water consumption of winter wheat in bed-planting is lower than that in flat planting, and dry matter accumulation is higher than that of flat planting. Compared with the flat planting, the water quantity of bed-planting can be saved 40%, the production can increase by 5.5% to 11.3%, and water use efficiency can increase by 0.17 to 0.40kg/m^3. On the basis of the experimental results, it is suggested that the bed-planting mode in combination with considerably deficit irrigation at winter, jointing and booting stages is worth extending the application in winter wheat production.

INTRODUCTION

At present, there is a shortage of water resources in most areas of China, but agricultural water waste phenomena are very serious, and the water resource shortage and inefficient utilization coexist, which increase the degree of water resources shortage. The utilization rate of agricultural irrigation water is very low in these regions, less than 1 kg food production per 1m^3 of water, about 60% of the irrigation water has been wasted because of irrigation way, farmland irrigation infrastructure and so on. Due to evaporation of water in the field, less than one-third of the total amount of irrigation water is really used by the crops. Compared with developed countries there is very big disparity, so the development of water-saving irrigation is urgent (Sun & Kang 2000, Wang & Zhang 2002).

Compared with the traditional cultivation way, in wheat ridging cultivation water can be saved 30%, the humidity reduce about 10%, light transmittance increase by 5% ~ 15% on average and the rate of light energy utilization increase by 10%~13.8%. At the same time, the degree of lodging, plant diseases and insect pests significantly become lower than that of traditional cultivation patterns, and plant grows strong. Wheat ridging cultivation increases the yield by 10%~13.4% comparing with the traditional cultivation, and is widely used in a variety of crops in many countries currently (Wang & Wang 2004, Wang et al. 2003a, Wang et al. 2003b). According to study about several different water treatments on the way of winter wheat water consumption, the ground dry matter weight, yield and WUE, high yield and water-saving planting scheme are raised.

MATERIALS AND METHODS

General situations: The experiment position is situated at north latitude 35'33° and east longitude 111°25', located in warm temperate zone to the north subtropical transition zone and belongs to semi-humid partial dry climate, whose average temperature is 12° to 14.5° and the average yearly rainfall 637.1 mm. The earth for experiment is cinnamon soil and the experimental field is flat, so that is convenient for irrigation and drainage.

Test design: The specifications for wheat planting ridges and ditch is 70 cm and 40 cm, ridge high 20 cm, 4 lines of wheat are planted on the ridge, small row spacing of wheat is 14 cm and big row spacing is 22 cm (Fig. 1). The traditional culture of plantation is the flatten culture treatments, which strip for broadcast is 2.8 m wide, strip spaced planting and row spacing of 20 cm. Plot areas is 2.8 m × 15 m, 3 times repeat with randomized arrangement. Management measures are same to the field. Each set of plantation involves three irrigation processes and the specific irrigation scheme is given in Table 1. During the experiment without block rain, in the whole growth course of winter wheat, the total rainfall is 194.8 mm, perennial less than 11.9 mm, which distributes in late period of fertility. Fertilizer was raised water along the ridges.

Index of determination: Quantity of rainfall, soil moisture

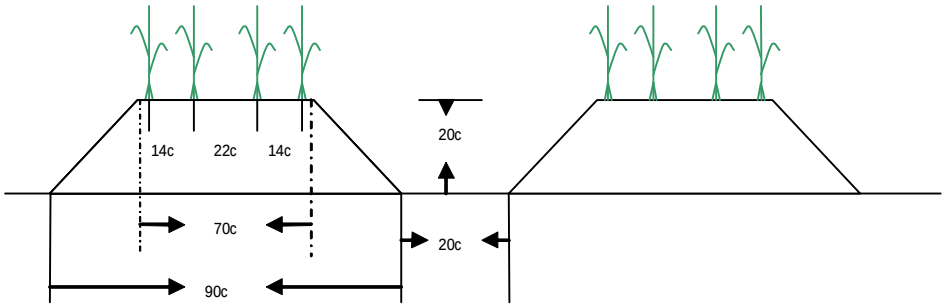

Fig 1: Schematic diagram of bed-planting.

content of winter wheat at different stages, the ground dry matter accumulation quantity, and yield were determined.

Determining method: Rainfall field meteorological data acquisition system using field conditions of collecting was used. Soil moisture content was determined by drying method, each 20 cm soil for one level, sounding 1 m. The drying method was used to determine the dry matter; and production method with sample amount. Water use efficiency is equal to the total average wheat grain dry weight per unit area compared with the total water consumption during whole growth stages.

RESULTS AND ANALYSIS

Influence of different water treatments on water consumption: From Table 2, it is known that in the whole growth period of winter wheat, the water consumption of different treatments is on the same trend that the water consumption reduces in the period of over-wintering to green returned stage, then gradually increases and reaches the highest point in the period of jointing to heading stage, and finally reduces again. In the stage of green returned and jointing, because treatment L3 and P3 loses irrigation water, the difference of water consumption becomes the most obvious, less than the treatment of irrigation in the stage of green returned and jointing. Under the same irrigation condition, the irrigation water consumption in ridge is less than that in culture from sowing to heading, but bigger than flat culture from heading to mature; this period is an important period for forming wheat, and is closely related to the production, so the addition of water consumption in ridge can help to improve the yield of winter wheat.

No matter what is ridge or the culture, with the addition of irrigation frequency and the increase of irrigation water, water consumption of winter wheat would increase, relevant research results are consistent (Zhang 2003). In the same irrigation water treatment, water consumption of culture is about 3%-17% more than the water consumption of ridge; the same cropping pattern in different irrigation conditions, irrigation water consumption of planting pattern for ridge is four water irrigation water > three water irrigation > two water irrigation. Each treatment with the same total rainfall shows that irrigation water has a great impact on the water consumption. The ridge cultivation can reduce the water consumption of winter wheat, in the period of over-wintering and booting stage, water consumption is minimized.

Influence of different water treatments on dry matter: Table 3 shows that, because before the treatment period, irrigation frequency is identical, in the stage of green returned, dry matter has little difference. And then with the growth of winter wheat and the change of irrigation frequency, the ground dry matter accumulation also appears some difference, the specific performance of four water irrigation > three water irrigation > two water irrigation, but because the heading rainfall becomes more than before, the influence of irrigation frequency on ground dry matter becomes less obvious. In the same irrigation frequency, the accumulation of dry matter raises more than that of the culture, which becomes most obvious in maturity; the difference of grain is the largest in irrigation 3 water, that is the winter water + jointing water + booting water, the difference is 5.56 g/10 plants.

Influence of different water treatments on yield: Under the different irrigation situations, the yield of bed-planting winter wheat show three water irrigation > four water irrigation > two water irrigation; the yield of three water irrigation increases 2.9% and 5.3% to respectively the yield of four water irrigation and two water irrigation. The booting rate of four water irrigation treatment is high, but the grain grouting effect is bad, grain weight is less than that of three water irrigation treatment, so that the yield reduces. In culture-planting, winter wheat yield with irrigation frequency increased. In the same treatment with different planting modes of irrigation, production per hectare is higher 392 kg to 782 kg than that of the culture raised , which is most obvious in three water irrigation conditions; increased rate of production is 11.3%, as shown in Table 4.

Table 1: Irrigation of winter wheat with different treatment options (m^3/hm^2).

Treatment with numbers	Over-wintering stage	Green returned stage	Jointing stage	Booting stage	Total irrigation water	irrigation methods
L1	450	450	450	450	1800	Furrow irrigation
P1	750	750	750	750	3000	Border irrigation
L2	450	450	-	450	1350	Furrow irrigation
P2	750	750	-	750	2250	Border irrigation
L3	450	-	-	450	900	Furrow irrigation
P3	750	-	-	750	1500	Border irrigation

Table 2: Effect of irrigation on the water consumption of winter wheat (mm).

Treatment	Sowing~over-wintering stage	Over-wintering~ green returned stage	Green returned~ jointing stage	Jointing~ heading stage	Heading~ filling stage	Filling~ maturating stage	During whole growth stages water consumption
L1	62.02	31.16	76.60	130.26	59.14	35.28	394.47
P1	72.48	40.51	81.85	153.89	53.16	59.49	461.39
L2	58.06	24.77	77.83	113.17	46.43	49.18	369.45
P2	61.05	37.02	84.11	125.82	41.15	62.09	411.24
L3	64.85	23.45	28.96	111.73	78.40	53.10	360.49
P3	68.35	23.45	36.60	130.42	63.29	49.11	371.22

Table 3: Dry matter accumulation and distribution of winter wheat (g/10 plants).

Number ofirrigation	Treatment	Irrigation methods	Green returned stage	Heading stage	Maturating stage	Dry matter	
						Straw	Grain
Four	L1	Furrow irrigation	2.98	26.62	54.00	37.61	16.39
	P1	Border irrigation	3.85	25.21	42.85	28.34	14.51
Three	L2	Furrow irrigation	3.39	25.57	47.30	30.29	17.01
	P2	Border irrigation	3.34	23.77	35.65	24.20	11.45
Two	L3	Furrow irrigation	2.85	20.62	45.45	33.96	11.49
	P3	Border irrigation	4.45	16.21	33.90	21.54	12.36

Table 4: Yield and WUE of winter wheat under different irrigation treatments.

Treatment	Number of irrigations	Spike number (Million Spike/hm^2)	Grain number (Grain/Spike)	Thousand grain weight (g)	Yield (kg/m^2)	Total water consumption (mm)	WUE (kg/m^3)
L1	4	772.5	41.8	36.9	0.75	394.47	1.90
P1	4	750.0	41.4	38.0	0.71	461.39	1.54
L2	3	735.0	41.0	41.3	0.77	369.45	2.08
P2	3	588.0	43.5	38.2	0.69	411.24	1.68
L3	2	622.5	41.2	40.0	0.73	360.49	2.03
P3	2	664.5	36.1	37.1	0.69	371.22	1.86

Influence of different water treatments on water use efficiency: As bed-planting and flatten culture exist in the same field, the rainfall is identical. Each time the water amount raised in bed-planting was 450 m^3/hm^2, and every time the irrigation capacity of the flatten culture is 750 m^3/hm^2, water saving rate was 40%. Even in case of the irrigation water reducing, raised output in bed-planting is still higher than the culture; cultivation has raised water saving effect on increasing. From the Table 4, we can see that in different water treatments, water use efficiency changes with the irrigation frequency, which shows that water use efficiency increases at first and then reduces. Water use efficiency raised in three water irrigation cultivation is the highest, about 2.08 kg/m^3, followed by two water irrigation, in which water use efficiency is 2.03 kg/m^3. In the same water treatment, the treatment of the water use efficiency raises significantly higher than that of the traditional culture; the biggest difference is 0.4 kg/m^3.

CONCLUSIONS

The results of the study show that with each treatment with the increased winter wheat irrigation frequency and amount of irrigation, water consumption and the ground dry matter increased significantly, and yield and WUE reduced after first increase. Under the condition of the three irrigations in the bed-planting raised in the test set planting pattern of the three irrigation conditions, all the water consumptions are less than that of the traditional culture; yield and water use efficiency are higher than that of the traditional culture. Relative to the flat culture, ridge planting can save water up to 40%. In the period of irrigation in over-wintering stage and booting stage, the yield can increase 6.6%. In the period of irrigation in over-wintering stage, green returned stage, jointing stage and booting stage, the yield can increase 5.5%. When irrigation in over-wintering stage, green returned stage, jointing stage and booting stage, the yield can reach the highest point compared with the traditional culture. The effect of bed-planting is most significant, which can increase by effect on increasing traditional culture and increased yield rate was, 11.3%, and at this time the WUE is highest, the value was 2.08 kg/m^3. Taking winter wheat water consumption, yield and WUE relationship as a whole to consider, ridge planting combined with irrigation in over-wintering stage, jointing stage and booting stage, is worth promoting cropping patterns.

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REFERENCES

Sun, J.S. and Kang, S.Z. 2000. Our country present situation of water resources utilization and development countermeasures of water-saving irrigation. Journal of Agricultural Engineering, (2): 1-5.

Wang, L.S. and Zhang, L.L. 2002. The western agricultural water resources of equal analysis and control way. Journal of Luoyang Agricultural College, 23(3): 170-172.

Wang, X.Q., Wang, F.H. and Ren, D.C. 2003a. Raised in the field of the cultivation of wheat eco-microclimatical effects of plant growth and yield and the influence. Journal of Chinese Agricultural Meteorology, 2: 5-8.

Wang, X.Q., Wang, F.H. and Yu, Z.W. 2003a. Raised on individual development and cultivation of wheat the influence of resistance. Farming and Planting, 5: 21-23.

Wang, F.H. and Wang, X.Q. 2004. Comparison of conventional, flood irrigated, flat planting with furrow irrigated, raised bed planting for winter wheat in China. The Field Crops Res., 87: 35-42.

Zhang, Z.X. 2003. Different water treatment on winter wheat growth and the influence of water use efficiency. Journal of Irrigation and Drainage Water, 23(2).