Irrigation scheduling for corn in a coastal saline soil

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Abstract: Currently, water scarcity is serious and the irrigation scheduling with efficient water use becomes important in China. In this study, irrigation systems were scheduled in the saline area along Laizhou Bay. Field study was conducted to determine the relation of irrigation regime and crop yield from 2010 to 2012, and the representative rainfall years (high-flow year, normal-flow year and low-flow year) were calculated by analyzing rainfall frequency over 30 years. Six irrigation regimes were set according to local farmers' practices. Irrigation amounts of T1, T2, T3, T4, T5 and T6 were 225.0 mm, 270.0 mm, 337.5 mm, 300.0 mm, 360.0 mm and 450.0 mm, respectively, with the same frequency of four times. The results showed that soil salt content decreased with the increase of irrigation water amounts. The corn yield varied from 6560 kg/hm^2 to 8060 kg/hm^2. The highest yield was obtained from T5. Production functions related to irrigated water (I, mm) for corn yield (Y, kg/hm^2) was $Y = -0.0397I^2 + 1059.6$ ($R^2 = 0.8892$). Aiming at high corn yield, total water supply (irrigation and rainfall) to corn crops was 859 mm. Precipitation amounts at low-flow year (p=80%), normal-flow year (p=50%) and high-flow year (p=20%) were obtained by the simulation of rainfall frequency curve, which were 348 mm, 457 mm and 604 mm respectively in the whole growth period (from late June to mid-October). In order to obtain the highest theoretical corn yield, according to field results and rainfall, the optimum irrigation frequency at low-flow year, normal-flow year or high-flow year was four times for corn in the saline area along Laizhou Bay.

Keywords: corn (*Zea mays*), irrigation regime, desalination, rainfall, soil salinity
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1 Introduction

Corn is one of the most staple crops in North China Plain, where 70% of the arable is under double cropping system of summer corn and winter wheat[1]. Corn is also a water-consumable crop. With increasing municipal and industrial demands for water, water allocation for agriculture is decreasing steadily[2]. A great challenge for the agricultural sector is to produce more food using less water[3]. Several possible approaches such as improving irrigation technology and efficient irrigation scheduling might be adopted for more efficient use of limited water resources[4]. Saline soils cover an area of about 3.46 billion hm^2 in China, including 7.6 million hm^2 salinized farmland which accounts for 20% of the total saline soil[5]. The soil salt content is one of the most important limiting factors to crop yield[6-10], and salts move as water flows[11,12]. The water resource is of shortage and the water distribution is

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of unbalance in China. As a result, the soil salinization and shortage of water resources become the critical factors to restrict the development of agriculture[10,13-17]. As farmland resources get spare in China[18], the reasonable utilization and improvement of saline soil have become the most important aspect of agricultural sustainable development. Laizhou urban area is located along the coastwise of Laizhou Bay and the west edge is close to Jiaodong Hills. It belongs to a coastal plain of low attitude, which is easily intruded by seawater. Because of the over-exploitation of the underground water, the sea water invasion takes place on a large scale which brings big damage to local industries, agriculture and their daily life[19,20]. There is more than 50 million kg of agricultural food reduction caused by sea water invasion every year[21]. Irrigation water amount is related to rainfall, which changes greatly every year. Soil drought degree can be classified into normal-flow year, low-flow year, and high-flow year by rainfall frequency. Through the field experiment of soil salinity and production of corn under different irrigation systems and analysis of the rainfall frequency curve, this article aims at offering theoretical and practical bases for optimum irrigation for the local corn production.

2 Materials and methods

2.1 General situation of experimental site

The experiment was carried out from June 2010 to October 2012 at the Zhuwang village (37º06'18.72"N, 119º57'46.08"E) in Laizhou city, China (Figure 1). The site is located in the warm semiarid climate zone. The northwest of the site is close to Laizhou Bay and 1.2 km away from the sea. The annual average temperature is 12.4ºC, annual average rainfall is 645 mm and annual average evaporation is 2116.2 mm. The rainfall is low and evaporation is high in spring, with a total evaporation of 898.7 mm from April to June. The site is in the low plain along coast, with a sandy loam soil characterized by a soil bulk density of 1.20 g/cm^3, salinity of 2.09 dS/m and pH 8.23 in the 0-0.2 m layer. The underground water level is between 0.75 m and 1.78 m.

Figure 1 The experimental area in Zhuwang village, China

2.2 Experimental design

Corn seeds were sown at the end of June in 2010, 2011 and 2012. Fertilizer was applied uniformly to each treatment when the soil was ploughed, including ammonium bicarbonate (NH_4HCO_3) 100 kg/hm^2 and the urea ($CO(NH_2)_2$) 200 kg/hm^2. The corn variety was 'Denghai 3622'. Planting was in a twin-row form, with the wide row space as 0.75 m and the narrow as 0.50 m. The space between plants in a row was 0.25 m. Six irrigation regimes with different irrigation amounts and frequencies were designed in reference to local farmers' conventional practices (three times of irrigation each with 337.5 mm of water). In this study, six treatments, T1, T2, T3, T4, T5 and T6, were designed with the total irrigation amount as 225.0 mm, 270.0 mm, 337.5 mm, 300.0 mm, 360.0 mm and 450.0 mm, respectively, which were 0.67, 0.80, 1.00, 0.89, 1.06 and 1.33 times of conventional irrigation water amount. Irrigation frequencies were all three times for T1, T2 and T3, and 4 times for T4, T5 and T6. Irrigation water was delivered to the experimental plots by underground pipelines. Furrow irrigation was adopted and the water amount was controlled by water meter in the irrigation pipe. The salt content of irrigation water was 1.088 g/L and pH was 7.52. Each treatment covered an area of 67 m^2 and a random block experimental design was adopted with three replications, as shown in Table 1. Weed and pest controls were managed uniformly according to standard practices. Harvest was done in early October. Winter wheat was planted after the corn was harvested. The winter wheat was irrigated three times with the total water amount of 300 mm.

Table 1 Different irrigation regimes of the corn crops in 2010, 2011 and 2012

	Treatments	Irrigation frequency	Irrigation amount at different stages/mm				Total amount/mm
			Seed (6/30)	V8(7/24)	V12(8/7)	R2(9/7)	
2010	T1	3	75	-	75	75	225
	T2	3	90	-	90	90	270
	T3	3	112.5	-	112.5	112.5	337.5
	T4	4	75	75	75	75	300
	T5	4	90	90	90	90	360
	T6	4	112.5	112.5	112.5	112.5	450
2011			Seed (6/28)	V8(7/21)	V12(8/3)	R2(9/5)	
	T3	3	112.5	112.5	-	112.5	337.5
	T4	4	75	75	75	75	300
	T5	4	90	90	90	90	360
2012			Seed (6/30)	V8(7/26)	V12(8/6)	R2(9/8)	
	T3	3	112.5	112.5	-	112.5	337.5
	T4	4	75	75	75	75	300

Corn growth stages were divided into vegetative (V) and reproductive (R) stages[22]. The V stages were designated numerically as V1, V2, V3, and Vn, where n represents the number of leaves with visible collars. The collar is where the leaf blade visually breaks away from the sheath and the stalk of the corn plant. The six reproductive stages are simply designated numerically as follows:

R1 (Silking) - silks visible outside the husks;

R2 (Blister) - kernels are white and resemble a blister in shape;

R3 (Milk) - kernels are yellow on the outside with a milky inner fluid;

R4 (Dough) - milky inner fluid thickens to a pasty consistency;

R5 (Dent) - nearly all kernels are denting;

R6 (Physiological maturity) - the black abscission layer has formed.

2.3 Experimental methods

Soil samples from the layers of 0-5 cm, 5-20 cm, 20-40 cm, and 40-60 cm were collected, prepared and sieved to 1 mm after natural dry. Measure the soil electrical conductivity (METTLER TOLEDO FE30) and soil total salinity respectively[23], and then calculate the conversion formula. The total salinity shown by salt content (C_S) was calculated based on the formula as followed:

$$C_S(‰)=(EC/10000-0.0015)/3.9\times1000$$

where, EC was soil electrical conductivity, mS/m. The soil desalination rate was determined by the following Equation:

$$Ds=\frac{C_0-C}{C_0}\times100\%$$

where, Ds was soil desalination rate, %; C_0 was the original salt content, g/kg; C was salt content after crop harvest, g/kg.

Irrigation water productivity (IWP) was estimated as

$$IWP=Y/I$$

where, Y was crop yield, kg/hm^2; I was irrigation water applied, mm[24].

2.4 Statistical analysis

All data were processed with Excel 2003 and SPSS 17.0. Comparisons ($p<0.05$) of each variable among treatments were conducted with Tukey's test by using SPSS 17.0.

3 Results and discussion

3.1 Influences of irrigation regimes on soil salinity and soil desalination rate

The soil salt content was measured during the growth period (2010-2012). The experimental plots for each treatment were close to each other with a similar soil salt content. Thus, we averaged the soil salt contents in experimental plots as initial soil salinity on 29 June 2010. After harvest, the soil salt content in T6 was 1.21‰ and lower than those in other treatments on 13 October 2010 (Table 2). The soil desalination rate (Ds) in T6 was 75.9%, significantly higher ($p<0.05$) than those in other treatments. It was suggested that the more irrigation water was applied, the higher the Ds could be. A total of 337.5 mm and 300.0 mm water were applied to T3 and T4, respectively. There were no significant difference in *D*s between T3 and T4, which was possibly due to more irrigation water each time and lower irrigation frequency in T3 than in T4. The total rainfall from November to May occupies only 12% of the average annual rainfall. Thus, soil resalination in the experimental site was serious during the winter wheat growth period. The surface soil (0- 5 cm) salt content exceeded 3‰ on 27 June 2011 and 29 June 2012 (Table 3 and 4). Then, soil salt decreased as the time went on. *D*s in 2011 were 54.9%, 54.8% and 57.7% in T3, T4 and T5, respectively. *D*s in 2012 were 55.2% and 54.7% in T3 and T4, respectively. There were no significant differences in soil desalination between T3 and T4. Compared to 2010, *D*s decreased in 2011 and 2012 due to the declining of rainfall. In addition, all treatments in this experiment resulted in good soil desalination during corn growth period and this might be attributed to the high rainfall and low evaporation.

Table 2 Total soil salt in different soil layers influenced by different irrigation systems (2010)

Treatments	Soil depth/cm	Soil salt content/‰						Soil desalination rate (*Ds*)/% (in 0-60 cm layer)
		Jun. 29	Jul. 3	Jul. 18	Aug. 15	Sep.15	Oct.13	
T1	0-5	5.01	4.64	4.22	2.24	1.72	1.59	68.7 d
	5-20	4.97	4.45	4.14	2.19	1.68	1.55	
	20-40	4.65	4.13	3.90	2.06	1.57	1.45	
	40-60	4.60	4.10	3.83	2.02	1.54	1.42	
T2	0-5	5.01	4.35	4.02	2.08	1.54	1.47	70.9 cd
	5-20	4.97	4.23	4.00	2.07	1.53	1.42	
	20-40	4.65	4.09	3.87	2.00	1.47	1.36	
	40-60	4.60	4.08	3.83	1.98	1.46	1.35	
T3	0-5	5.01	4.26	3.94	1.99	1.42	1.45	72.2 bc
	5-20	4.97	4.10	3.81	1.92	1.37	1.41	
	20-40	4.65	4.07	3.82	1.93	1.37	1.27	
	40-60	4.60	4.07	3.74	1.88	1.34	1.24	
T4	0-5	5.01	4.57	4.20	2.09	1.59	1.43	72.1 bc
	5-20	4.97	4.41	4.09	2.03	1.55	1.37	
	20-40	4.65	4.15	3.77	1.86	1.41	1.30	
	40-60	4.60	4.06	3.67	1.81	1.37	1.26	
T5	0-5	5.01	4.41	4.06	1.97	1.45	1.34	73.7 b
	5-20	4.97	4.14	3.92	1.89	1.39	1.29	
	20-40	4.65	4.07	3.81	1.84	1.35	1.24	
	40-60	4.60	3.98	3.63	1.75	1.28	1.18	
T6	0-5	5.01	4.24	3.91	1.85	1.31	1.21	75.9 a
	5-20	4.97	4.18	3.85	1.82	1.29	1.19	
	20-40	4.65	4.05	3.73	1.75	1.24	1.14	
	40-60	4.60	4.05	3.60	1.69	1.19	1.10	

Note: Distinct letters in the row indicate significant differences according to Tukey's test ($p≤0.05$). The same below.

Table 3 Total soil salt in different soil layers influenced by different irrigation systems (2011)

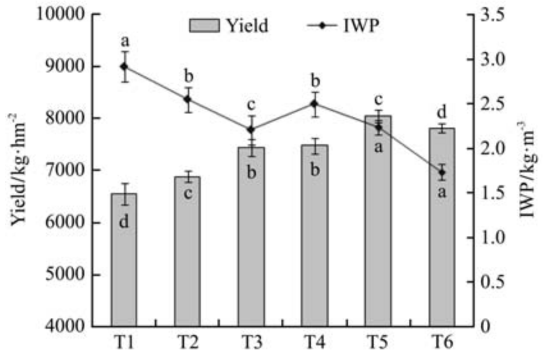
Treatments	Soil layer/cm	Soil salt content/‰						Soil desalination rate/% (in 0-60 cm layer)
		Jun. 29	Jul. 3	Jul. 18	Aug. 15	Sep.15	Oct.13	
T3	0-5	3.75	3.42	3.08	2.75	2.29	1.78	54.9 a
	5-20	3.65	3.23	2.91	2.60	2.03	1.65	
	20-40	3.53	3.13	2.83	2.58	2.00	1.58	
	40-60	3.43	3.10	2.73	2.54	1.83	1.46	
T4	0-5	3.74	3.34	3.00	2.66	2.18	1.76	54.8 a
	5-20	3.64	3.10	2.94	2.52	1.98	1.66	
	20-40	3.52	2.98	2.74	2.48	1.83	1.62	
	40-60	3.41	2.94	2.65	2.42	1.81	1.50	
T5	0-5	3.61	3.27	3.04	2.58	2.14	1.72	57.7 a
	5-20	3.59	3.05	2.92	2.46	1.89	1.54	
	20-40	3.48	2.93	2.71	2.43	1.81	1.41	
	40-60	3.45	2.91	2.60	2.38	1.72	1.30	

Table 4 Total soil salt in different soil layers influenced by different irrigation systems (2012)

Treatments	Soil layer/cm	Soil salt content/‰						Soil desalination rate/% (in 0-60 cm layer)
		Jun. 29	Jul. 3	Jul. 18	Aug. 15	Sep.15	Oct.13	
T4	0-5	3.08	2.79	2.51	2.24	1.91	1.45	55.2 a
	5-20	2.97	2.64	2.36	2.11	1.70	1.37	
	20-40	2.94	2.54	2.30	2.10	1.63	1.31	
	40-60	2.92	2.52	2.22	2.07	1.49	1.21	
T5	0-5	3.14	2.72	2.44	2.17	1.77	1.44	54.7 a
	5-20	2.96	2.52	2.39	2.04	1.61	1.35	
	20-40	2.86	2.43	2.23	2.02	1.49	1.31	
	40-60	2.78	2.39	2.16	1.97	1.47	1.22	

3.2 Yield of corn and irrigation water productivity influenced by irrigation systems

Yield and irrigation water productivity for the different treatments are shown in Figure 2. Harvest of corn began on 13 October in 2010 and 2011, and 14 October in 2012. Crop yields in T3, T4 and T5 were calculated by averaging the data from 2010 to 2012. T5 was the best with average crop yield as high as 8060 kg/hm^2, while the yields were 6560 kg/hm^2, 6893 kg/hm^2, 7445 kg/hm^2, 7484 kg/hm^2 and 7824 kg/hm^2 in T1, T2, T3, T4 and T6, respectively. In general, crop yield increased as irrigation water amount increased. The increase in corn yield in T5 might be attributed to low soil salinity. Crop yield was significantly higher in T5 and T6 than those in other treatments. However, crop yield in T6 was lower than that in T5 even the applied irrigation amount in T6 was higher than that in T5. The lower crop yield in T6 than that in T5 might be attributed to the excessive irrigation water that might cause leaching of soil nutrients. Crop yield with irrigation of 300.0 mm in T4 was higher than that with 337.5 mm of water in T3 and this might be due to increased irrigation frequency.



Note: Distinct letters in the row indicate significant differences according to Tukey's test (p≤0.05).

Figure 2 Corn yield and irrigation water productivity influenced by different irrigation systems (2010-2012)

Irrigation water productivity (IWP) was the relation between yield produced and the irrigation water used. Irrigation regime showed significant effects on IWP (Figure 3). IWP was the highest (2.92 kg/m^3) in T1 and, the lowest (1.74 kg/m^3) in T6. This was due to the further lower irrigation water. IWP declined dramatically from T1 to T3 and from T4 to T6 because yield improvement in T3 and T6 was less than the percentage increase in irrigation water as compared to T1 and T4. In general, the irrigation water productivity was decreased with the increases in irrigation water amount. The reason may be that excessive water can dilute soil nutrient contents, and fertilizer like NH_4HCO_3, $CO(NH_2)_2$, etc. will move down from surface layers of soil to deeper levels.

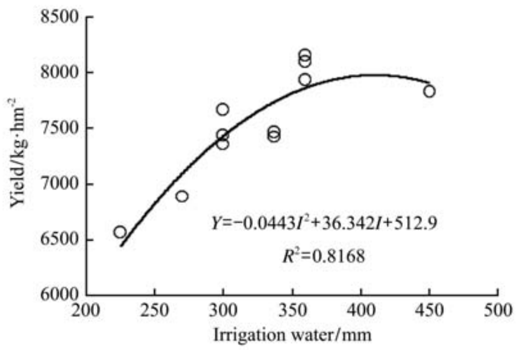


Figure 3 Relationship between irrigation water amounts and corn yield

3.3 Relationship between irrigation amount and crop yield

In the experiment, there were production functions in relation of the total amount of applied irrigation water with the corn yield (Figure 3). Good quadratic equation relationships between irrigation water and crop yield were obtained from 2010 to 2012. R^2 (0.8168) was lower than that (0.99) reported by Payero[25]. This might be due to the saline soil. Production functions related to irrigated water (I, mm) for corn yield (Y, kg/hm^2) was $Y = -0.0443I^2 + 36.342I + 512.9$ ($R^2 = 0.8168$). According to the above formula, theoretical crop yield was the highest (7966 kg/hm^2) when irrigation amount was 410 mm.

3.4 Scheduling for irrigation regime

Figure 4 shows the annual rainfall from 1980 to 2012 in Laizhou Bay. The average rainfall was 666.7 mm from 1980 to 1989, 783.6 mm from 1990 to 1999, and 657 mm from 2000 to 2012. It was concluded that rainfall was changed on time-scale of 10 years. In this research, data of precipitation from 2001 to 2012 were used to analyze the rainfall frequency curve at the experimental site.

Annual rainfalls of Laizhou Bay from 2001 to 2012 were presented in Table 5. The annual average rainfall ($\overline{R}$) was determined by the following equation:

$$\overline{R} = \frac{\sum_{i=1}^{n} Ri}{n} = 654.4$$

where, n is the number of years; R_i is rainfall per year, mm.

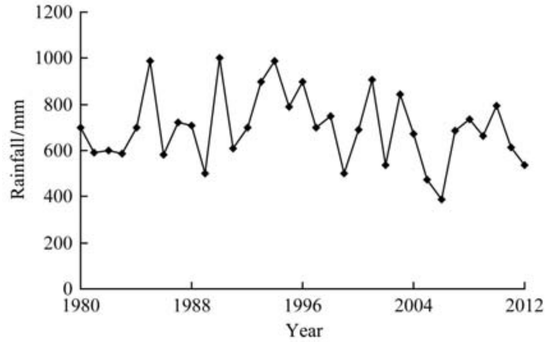


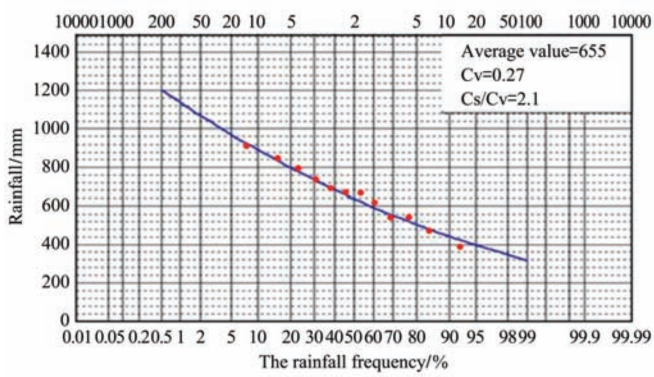
Figure 4 Annual average rainfall from 1980 to 2008

Table 5 Rainfall of Laizhou Bay from 2001 to 2012

unit: mm

Year	Jan.	Feb.	Mar.	Apr.	Ma.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual rainfall
2001	33.6	16.3	6.3	34.9	5.0	108.7	388.9	155.9	70.9	54.6	20.8	10.2	906.1
2002	11.6	0	17.8	33.3	86.4	35.2	216.1	63.9	18.2	36.4	9.3	8.4	536.6
2003	8.3	11.1	18.5	59.9	43.8	110.5	99.1	307.5	89.9	42.6	46.2	8.1	845.5
2004	6.2	4.6	6.2	18.4	97.3	69.3	236.9	155.0	25.5	7.1	22.2	21.3	670.0
2005	0.2	18.5	0.6	33.0	45.4	44.5	130.9	104.5	70.8	13.3	2.2	8.9	472.8
2006	2.3	13.7	5.5	31.5	72.7	36.8	75.0	113.1	13.3	15.5	3.4	6.4	389.2
2007	4.6	0.9	82.4	5.0	29.3	45.2	143.0	234.5	93.8	44.1	0.0	4.5	687.3
2008	6.4	3.2	17.3	32.5	106.3	23.9	288.0	193.8	29.3	14.3	9.1	12.6	736.7
2009	0.3	6.7	21.9	38.3	27.4	36.0	250.9	182.2	3.3	52.9	33.9	10.4	664.2
2010	11.4	17.8	28.5	39.2	41.8	55.8	248.9	250.9	78.7	7.1	4.1	8.3	792.5
2011	5.7	28.1	0.0	8.4	124.6	46.6	89.4	111.1	135.1	38.9	27.8	31.8	615.7
2012	0.7	2.9	2.2	24.6	35.5	27.7	139.6	161.8	43.0	45.2	28.2	25.3	536.6
Average	7.6	10.3	17.3	29.9	59.6	53.4	192.2	169.5	56.0	31.0	17.3	13.0	654.4

Soil drought degree can be expressed by rainfall frequency, which was mainly classified into normal-flow year (p=50%), low-flow year (p=80%), and high-flow year (p=20%). The rainfall frequency curve was performed using Pearson-Ш distribution curve on the basis of annual rainfall from 2001 to 2012 (Figure 5). One hundred-year rainfall (p=1%) and one thousand-year rainfall (p=0.1%) can be given as 1138.21 mm and 1346.11 mm, respectively. Rainfalls of three representative years including the year with the occurrence probability of 20% (high-flow year), the year with the probability of 50% (normal-flow year) and the year with the probability of 80% (low-flow year) was 796.92 mm, 638.37 mm and 503.43 mm, respectively. According to annual rainfall, typical years including 2005, 2008 and 2010 were chosen to represent low-flow year, normal-flow year and high-flow year, respectively. Rainfalls of representative years were educed by zooming the flowing process of typical years (Table 6).



Note: Cv: the coefficient of variation.

Figure 5 Rainfall frequency curve

Table 6 Rainfall process of representative years

unit: mm

Years	Rainfall	Jan.	Feb	Mar	Apr	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual rainfall
Low-flow year (*p*=80%)	Theoretical rainfall	0.2	19.7	0.6	35.1	48.3	47.3	139.3	111.2	75.3	14.2	2.3	9.5	503.1
Typical year (2005)	Rainfall	0.2	18.5	0.6	33.0	45.4	44.5	130.9	104.5	70.8	13.3	2.2	8.9	472.8
Normal-flow year (*p*=50%)	Theoretical rainfall	5.5	2.8	15.0	28.2	92.2	20.7	249.7	168.0	25.4	12.4	7.9	10.9	638.7
Typical year (2008)	Rainfall	6.4	3.2	17.3	32.5	106.3	23.9	288.0	193.8	29.3	14.3	9.1	12.6	736.7
High-flow year (*p*=20%)	Theoretical rainfall	11.5	17.9	28.7	39.4	42.1	56.1	250.4	252.4	79.2	7.1	4.1	8.3	797.3
Typical year (2010)	Rainfall	11.4	17.8	28.5	39.2	41.8	55.8	248.9	250.9	78.7	7.1	4.1	8.3	792.5

In corn growth period (from late June to middle October), precipitation at low-flow year, normal-flow year and high-flow year was 348 mm, 457 mm and 604 mm, respectively (Table 7). Based on the function between irrigated water (*I*, mm) and crop yield (*Y*, kg/hm^2), the highest yield could be obtained when irrigation amount was 410 mm, which was distributed through four growth stages of the corn crop evenly. From 2010 to 2012, average rainfalls at sowing time (late June), V8 stage (July), V12 (August) and R2 (September-middle October) were 14 mm, 159 mm, 175 mm and 101 mm, respectively. Aiming at high corn yield, total water supplied to corn crops was 859 mm and obtained together with irrigation amount of 410 mm and average rainfall of 449 mm. Water supplies at late June, July, August, and September-middle October were calculated as 117 mm, 262 mm, 278 mm and 203 mm, respectively, during the field experiment. Therefore, by using the principle of water balance, irrigation scheduling of corn was obtained in different representative years. Irrigation water amounts at low-flow year, normal-flow year and high-flow year were 517 mm, 408 mm and 261 mm, respectively.

Table 7 Irrigation scheduling during the corn growth stage in Laizhou Bay, China

unit: mm

Representive years		Late Jun. (Seed)	Jul. (V8)	Aug. (V12)	Sep.-mid Oct. (R2)	Total
Low-flow year (*p*=80%)	Rainfall	16	139	111	82	348
	Irrigation amounts	101	123	166	121	511
Normal-flow year (*p*=50%)	Rainfall	7	250	168	32	457
	Irrigation amounts	110	12	109	171	402
High-flow year (*p*=20%)	Rainfall	19	250	252	83	604
	Irrigation amounts	98	12	25	120	255

4 Conclusions

This study analyzed the rainfall frequency curve and evaluated the effects of different irrigation regimes on soil salt content, corn yield, and irrigation water productivity from 2010 to 2012 by field experiment close to Laizhou Bay, China. Irrigation scheduling for corn crops under different representative rainfall years was determined according to field research results. During both seasons, the soil salt decreased with increasing irrigation water amount. Average corn yields were 6560 kg/hm^2, 6893 kg/hm^2, 7445 kg/hm^2, 7484 kg/hm^2, 8060 kg/hm^2 and 7824 kg/hm^2 when irrigation water amounts were 225.0 mm in T1, 270.0 mm in T2, 337.5 mm in T3, 300.0 mm in T4, 360.0 mm in T5 and 450.0 mm in T6, respectively. Irrigation water productivity was increased with the increase of irrigation water amount at the beginning, and then decreased. The relationship between applied irrigation water amount and corn yield could be fitted by a quadratic equation, and theoretical maximum crop yield can be estimated from the curve. Rainfalls of three representative years including high-flow year (i.e. *p*=20%), normal-flow year (i.e. *p*=50%) and low-flow year (i.e. *p*=80%) were obtained from the rainfall frequency curve, which was simulated by using Pearson-Ш distribution curve on the basis of annual rainfall from 1980 to 2012 (provided by Laizhou Weather Bureau). Therefore, based on the function between irrigated water amount and crop yield, irrigation scheduling for corn crops was obtained for different representative years. Irrigation water amounts were 511 mm, 402 mm and 255 mm at low-flow year, normal-flow year and high-flow year, respectively. Farmers can irrigate corn crop by following the irrigation schedule under different representative years, for example, it can give low irrigation amount under high-flow year and high irrigation amount under low-flow year. At present, farmers often use traditional 'flooding method' in China, which means irrigation with excessive water during the period of crop. The best irrigation schedule in this experiment is simple to operate, and will change farmers' traditional irrigation methods significantly. Therefore, this research provides reference for determining irrigation schedule in saline land, and it can protect water resources and reduce groundwater pollution generated by fertilizer loss, especially meaningful in arid or semi-arid regions. Furthermore, it can be used for estimating the agricultural water demand of in a certain irrigation area, and provide the basis for water conservancy irrigation project design in China and other countries.

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