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Research article

IMPACT OF DEFICIT IRRIGATION ON THE DRY MATTER OF SORGHUM BIOCOLOR BY ALTERNATE FURROW AND CONVENTIONAL IRRIGATION METHODS

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ABSTRACT: In order to compare the alternate furrow and conventional irrigation methods and regimes and their effects on the dry matter accumulation process of sorghum bicolor (Payam variety) at different growth stages, this research was performed in a split plot experiment based on the randomized complete block method with three replications in the Zahak Agricultural Research Station. The main treatments considered included irrigation regimes (irrigation after 80, 130, and 180 mm accumulative evaporation from pan class A), and sub-treatments included irrigation methods (complete irrigation of furrows, Intermittent alternate furrow irrigation, fixed alternate furrow irrigation with two-line planting pattern, and this three irrigation methods with a line planting pattern and conventional irrigation). The results showed that the amount of dry matter in the aerial part of sorghum bicolor was significantly influenced by irrigation regimes, sampling stages, and irrigation methods. Moreover, the interaction between these factors and the rate of this factor was decreased by an increase in irrigation interval and a reduction in the soil's available moisture. The amount of dry matter in the aerial part of sorghum bicolor (338.2 gr/m^2) was more in the irrigation interval of 80 mm evaporation than that of the other irrigation regimes. An increase of (283.5 gr/m^2) was indicated in the accumulation process compared with the other stages in the third stage of sampling. The maximum amount of plant dry matter (333.3gr/m^2) was obtained from the conventional irrigation method. The results showed that the best performance pattern for this irrigation method for obtaining the maximum amount of dry matter is the fixed furrows method with a line planting pattern.
Keywords: Conventional irrigation, Alternate furrow, Sorghum bicolor, dry matter

INTRODUCTION

Sorghum ranks fifth among the world's most important crops. Its current world production stands at 64.58 million tons while in India current production is 7.4 million tons [1]. It serves as a raw material for food, fodder and many industrial products. Sorghum, which has drought adaptation capability, is a preferred crop in tropical, warmer and semi-arid regions of the world with high temperature and water stress [2]. Drought stress and water deficit is the most important non-living limiting factor of plant growth and production in the world [3]. Hence the effective use of water in irrigation for crop production has become a basic and important problem. With the development of new techniques in recent years, extensive efforts have been made with such methods as Regulated Deficit Irrigation (RDI), Controlled Alternate Partial Root-Zone Irrigation (CAPRI) and or Partial Root-Zone Drying (PRD) [4]. There are lots of studies about the effect of partial root-zone irrigation on growth, yield, WUE and quality of many crops. [5], Also indicated that when soil water content is 55–65% of field capacity, APRI reduces water consumption of maize by 34.4–36.8% but decreases the biomass by 6–12%, so increases WUE significantly. Compared to conventional irrigation (CI), APRI saves irrigation water by 29.1% but decreases total dry mass of sweet maize by 6.7%, thus it increases WUE by 24.3% under the fertilization and well-watered condition. in the Shiraz on the furrow irrigation of corn with periods of 4, 7, and 10 ordinary days and alternate irrigation and their subsequent economic survey, [6] showed that alternate furrow irrigation at an interval of 4 days on the treatment of furrow irrigation of ordinary 7 days used less water and had almost no reduction in product yield.

In their study, [7] observed no significant changes in product with furrow irrigation of sorghum with wide ridges spaced 2.48 m apart and ordinary ridges spaced 1.32 m apart, while the amount of water used in wide ridges was about half that used in ordinary furrow irrigation. [8] in their research on cotton showed that biomass and boll number decrease with the rate of reduction used water linear. [9] Studied 4 varieties of sorghum subjected to 4 intervals of irrigation at 7, 14, 28, and 42 days, root distribution, and amount of evaporation. Their results showed that the roots were shallow in irrigation at shorter intervals, and the water was absorbed from the soil surface. With circulative and alternate furrow irrigation, the amount of water used decreased during the season. [10] reported a 20-50% reduction of used water with alternate and deficit irrigation.

[11] showed that in sandy loam soil, the yield of sorghum bicolor was decreased by (1973 kg/hectare) with the use of 67% water in alternate furrow irrigation. The effective factors in the results of these studies were: underground water (water table) close to the ground surface, effective rainfall in growth season and type of plant (fruit, seed, root, or leaf production), irrigation interval and salinity of water irrigation, plant interaction with salinity and type and tissue of soil.

This study was conducted on the Sistan plain because of the restriction of water resources as well as the necessity for the development of new irrigation techniques among alternate furrow irrigation methods in order to improve the irrigation methods used in the region, to achieve suitable strategies of planting pattern management in the alternate furrow irrigation method, and to increase water productivity.

MATERIALS AND METHODS

Study site

This research was implemented in the Zahak Research Station located 25 kilometers southeast of the city of Zabol with an altitude of 483 meters above sea level. The average annual rainfall of the area is 55 mm, and the annual evaporation rate is 4000 to 5000 mm.

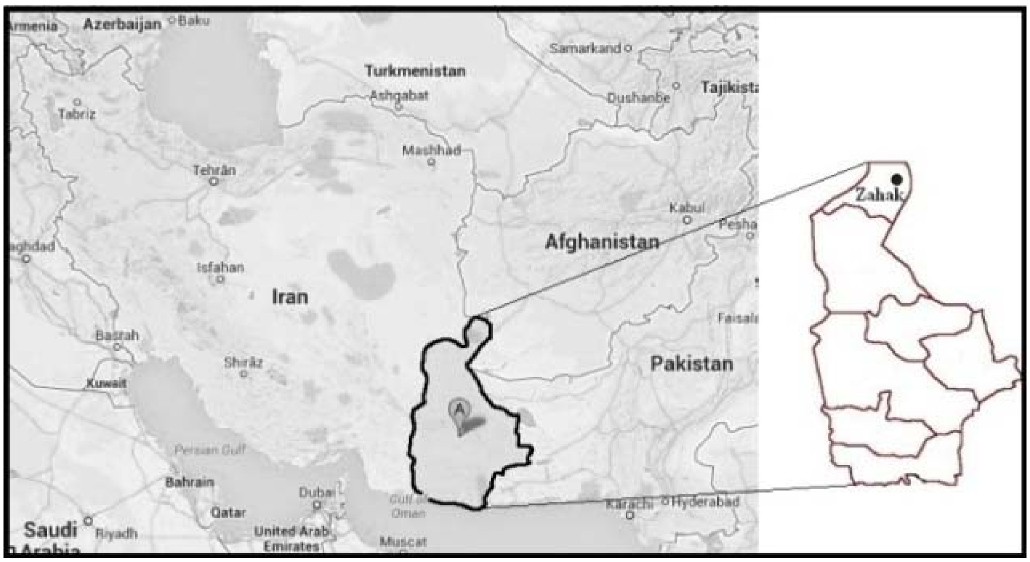

Fig-1: Zahak in southeast of Iran

Field experiments

The split block method was used in the form of randomized complete blocks with three applications in one year on grain sorghum. Main treatments included various irrigational regimes, such as irrigation after 80, 130, and 180 mm cumulative evaporation from pan class A. Sub-treatment methods complete irrigation of furrows (I1), Intermittent alternate furrow irrigation (I2), fixed alternate furrow irrigation with two-line planting pattern (I3), and complete irrigation of furrows (I4), Intermittent alternate furrow irrigation (I5), fixed alternate furrow irrigation (I6) with a line planting pattern and conventional irrigation (CI).

Table-1. Physical and initial chemical soil characteristics.

T.N.V (%)	K (mg/kg)	P (mg/kg)	OC (%)	EC(ds/m)	PH	Depth (Cm)
20	155	5	0.5	2	8	0-30
19	136	2.5	0.22	2	8.1	30-60
Gyps (%)	**ρb(gr/cm3)**	**CEC(ds/m)**	**PWP(%)**	**FC(%)**	**ESP**	**Depth (Cm)**
0	1.5	6.5	8	15	5.5	0-30
0	1.54	4.5	9	16	8.4	30-60

Stack width in the basin method was 50 cm. Soil samples were prepared from depths of 0-30 cm and 30-60 cm to test the average moisture content and specific weight of soil before cultivation. PWP and F.C. analyses were conducted. Main furrows were (11m×15m) and sub furrows were (4m×15m). There were 5 furrows with a length of 15 m and a stack width of 50 cm. Sub furrows were spaced approximately 1 m apart. Width and depth of furrows averaged 30 cm, and 12 kg of seed was used per hectare.
Soil moisture was also tested using an access tube at a 1-m depth by a probe T3 and a humidity detector device (TDR Model TRIME FM). In all three growth stages (Tillering, Jointing and Flowering), samples of roots and shoots were prepared to determine the dry weight of shoots.

RESULTS AND DISCUSSION

Results of the variance analysis (Table 2) showed that the effect of irrigation regimes, irrigation methods, sampling stages and also the interaction of each of these treatments on the dry matter accumulation rate in the aerial part of sorghum bicolor was significant at a 1% level.

Table-2: Variance analysis (A, B and C are irrigation names, irrigation methods and sampling stages respectively

S.O.V	df	MS
		Dry Matter
Repeat	2	3575.19**
A	2	340236.63**
Error	4	105.82
B	6	65122.66**
A×B	12	2009.04**
Error	36	294.90
C	2	1178509.39**
A×C	4	49096.17**
B×C	12	14400.82**
A×B×C	24	1381.06**
Error	84	377.75
CV (%)		7.45

***, * and ns are the significance level of %1, 5% and no significant respectively*

Results also showed that the produced dry matter of the aerial part sorghum bicolor was reduced when the irrigation interval was increased from 80 mm cumulative evaporation of pan class A to 180 mm evaporation. The maximum reduction rate of available moisture was found at the irrigation interval of 80mm evaporation (338.2 gr/m^2), and the minimum was in the irrigation interval of 180mm evaporation (191.9 gr/m^2) (Figure 2).

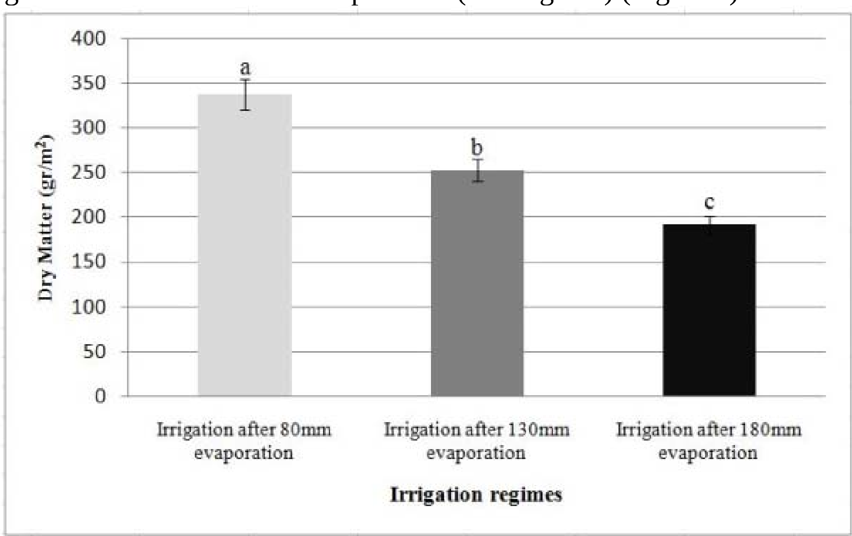

Fig-2: Effect of irrigation regimes on the dry matter of aerial part sorghum

Irrigation methods also had an effect on the dry matter accumulation rate in the aerial part of sorghum bicolor as the maximum amount of produced dry matter was (333.3 gr/m^2) using the conventional irrigation method and the minimum was (200 gr/m^2) with the fixed alternate furrow irrigation method with a line planting pattern (Table 3).

Table-3. Effect of irrigation methods on the dry matter of aerial part sorghum

Dry matter (gr/m^2)	Irrigation methods
308.8 ^{b}	complete irrigation of furrows with two-line planting pattern (I1)
252.4 ^{d}	intermittent alternate furrow irrigation with two-line planting pattern (I2)
217.8 ^{f}	fixed alternate furrow irrigation with two-line planting pattern (I3)
282.6 ^{c}	complete irrigation of furrows with a line planting pattern (I4)
232.2 ^{e}	intermittent alternate furrow irrigation with a line planting pattern (I5)
200.0 ^{g}	fixed alternate furrow irrigation with a line planting pattern (I6)
333.3 ^{a}	conventional irrigation (CI)

Table4. Effect of irrigation methods and irrigation regimes on the dry matter of aerial part sorghum

Dry matter (gr/m^2)			Irrigation methods
180 mm evaporation	130 mm evaporation	80 mm evaporation	
231.7 ^{i}	294.2 ^{efg}	400.6 ^{b}	complete irrigation of furrows with two-line planting pattern (I1)
177.3 ^{kl}	243.8 ^{hi}	336.1 ^{d}	intermittent alternate furrow irrigation with two-line planting pattern (I2)
156.8 ^{l}	212.7 ^{j}	283.9 ^{fg}	fixed alternate furrow irrigation with two-line planting pattern (I3)
212.6 ^{j}	277.7 ^{g}	357.6 ^{c}	complete irrigation of furrows with a line planting pattern (I4)
162.2 ^{ki}	234.1 ^{i}	300.2 ^{efg}	intermittent alternate furrow irrigation with a line planting pattern (I5)
145.7 ^{l}	201 ^{j}	253.2 ^{h}	fixed alternate furrow irrigation with a line planting pattern (I6)
256.8 ^{h}	307.3 ^{e}	435.7 ^{a}	conventional irrigation (CI)

The maximum amount ofaccumulative dry matter in the aerial part of sorghum bicolor between the sampling stages was obtained in the third sampling stage. Furthermore, the accumulative dry matter in the aerial part of sorghum bicolor was changed due to the interaction between irrigation regimes and methods (Table 4).
The maximum amount of dry matter was (435.7 gr/m^2) with the irrigation interval and conventional irrigation method and the minimum was with the fixed alternate furrow irrigation method with a line planting pattern. These results locate it in the same statistical group with produced dry matter in the aerial part of sorghum bicolor in an irrigation interval of 180 mm evaporation, fixed alternate irrigation of furrows with a two-line planting pattern in an irrigation interval of 180mm evaporation, alternative alternate irrigation of furrows with a two-line planting pattern, the amount of produced dry matter in the irrigation interval of 180 mm evaporation, and the alternative alternate irrigation of furrows with a line planting pattern the results of the averages comparison (Table 5) showed that the produced dry matter of the aerial part of sorghum bicolor was influenced by the interactions of irrigation regimes and sampling stages.

Table-5. Effect of irrigation regime and sampling stage on the dry matter of aerial part sorghum

Dry matter (gr/m2)			Irrigation regimes
Flowering	Jointing	Tillering	
89.24 ^{g}	114.1 ^{f}	136.9 ^{e}	Irrigation after 80mm evaporation
206.3 ^{d}	287.0 ^{c}	365.1 ^{b}	Irrigation after 130mm evaporation
280.0 ^{c}	357.9 ^{b}	512.5 ^{a}	Irrigation after 180mm evaporation

The maximum amount of dry matter was found in the irrigation interval of 80 mm evaporation and in the third sampling stage, and the minimum was found in the irrigation interval of 180 mm evaporation in one sampling stage. The maximum amount of produced dry matter in the aerial part of sorghum bicolor was obtained with the conventional irrigation method in the third sampling stage (515.8 gr / m^2). In this study the minimum amount of produced dry matter was obtained with the fixed alternate furrow irrigation method with a line planting pattern in one sampling stage (Table 6).

Table-6. Effect of irrigation methods and sampling stage on the dry matter of aerial part sorghum

Dry matter (gr/m2)			Irrigation methods
Flowering	**Jointing**	**Tillering**	
123.9 [kl]	242.2 [ij]	328.4 [e]	complete irrigation of furrows with two-line planting pattern (I1)
328.8 [e]	310.9 [ef]	98.78 [m]	intermittent alternate furrow irrigation with two-line planting pattern (I2)
473.8 [b]	117.9 [km]	234.3 [j]	fixed alternate furrow irrigation with two-line planting pattern (I3)
111.6 [lm]	300.9 [fg]	266.8 [h]	complete irrigation of furrows with a line planting pattern (I4)
286 [g]	429 [c]	133.7 [k]	intermittent alternate furrow irrigation with a line planting pattern (I5)
359.7 [d]	107.9 [lm]	350.3 [d]	fixed alternate furrow irrigation with a line planting pattern (I6)
100.2 [m]	260.2 [hi]	515.8 [a]	conventional irrigation (CI)

Previous studies show that alternate partial root-zone irrigation (APRI) decreased dry matter accumulation of maize when compared to the conventional irrigation [5, 12]. In this study, conventional irrigation compared with APRI methods. APRI methods decreased aerial part sorghum dry matter at the tillering stage.

CONCLUSION

The dry matter rate in forage sorghum influenced by different methods and regimes of deficit irrigation using the alternate furrow irrigation method showed that the best performance pattern for this irrigation method for obtaining the maximum amount of dry matter is the fixed furrows method with a line planting pattern. APRI methods decreased aerial part sorghum dry matter at the tillering stage which the least amounts of plant dry matter were obtained from the I2 and I5. Thus in the initial growth stage use of I2 and I5 methods don't suitable. In the Jointing and Flowering stages of growth can use these irrigation methods.

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