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Research Article

YIELD ATTRIBUTES AND YIELD OF *RABI* SORGHUM (*Sorghum bicolor L.* Moench) AS INFLUENCED BY DIFFERENT DRIP IRRIGATION LEVELS

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Abstract- The field experiment was conducted during *rabi* 2014-2015 with CSH-16 sorghum hybrid at Water Technology Center, College farm, College of Agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University, Hyderabad to study the effect of different drip irrigation levels i.e. drip irrigation at estimated 0.6 ETc throughout the life (I_1), 0.8 ETc throughout the life (I_2), 1.0 ETc throughout the life (I_3), 1.2 ETc throughout the life (I_4), 0.6 ETc up to flowering 0.8 ETc later on (I_5), 0.6 ETc up to flowering 1.0 ETc later on (I_6), 0.6 ETc up to flowering 1.2 ETc later on (I_7), 0.8 ETc up to flowering 1.0 ETc later on (I_8), 0.8 ETc up to flowering 1.2 ETc later on (I_9) and in addition to surface furrow irrigation at 0.8 IW/CPE ratio (I_{10}) on yield attributes and yield of *rabi* sorghum. The results indicated that drip irrigation at estimated 1.2 ETc throughout the life recorded higher yield and yield attributes compared to the drip irrigation treatments and surface furrow irrigation at 0.8 IW/CPE ratio. Under deficit irrigation conditions, drip irrigation at 0.8 ETc up to flowering and 1.0 or 1.2 ETc later on can be recommended over the drip irrigation 1.0 to 1.2 ETc throughout the life with minimum reduction in yield.

Keywords- Drip Irrigation, Surface furrow irrigation, Sorghum grain yield and yield attributes.

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Introduction

Sorghum is the fifth most important cereal crop and is the dietary staple for more than 500 million people in 30 countries and grown in an area of 40 million ha in 105 countries of which USA, India, Mexico, Nigeria, Sudan and Ethiopia are the major sorghum producers. The area of sorghum in India is 6.10 million ha [2012-13], out of which 3.78 million ha in the post rainy (*rabi*) season and incase of Telangana it is grown in 1.09 lakh ha area with productivity of 1015 kg ha^{-1}, respectively [4]. Water is increasingly becoming scarce because of erratic distribution of monsoons and uncontrolled exploitation of ground water. The global challenge for the coming decades is to increase the food, fodder and fiber production, with less utilization of water and as water is a limiting input in near future. The present experiment initiated to maximize yield attributes and yield of *rabi* sorghum with less water.

Materials and Methods

During *rabi* 2014-2015, the field experiment was conducted with CSH-16 sorghum hybrid at Water Technology Center, College farm, College of Agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University, Hyderabad on a sandy clay loam soil, alkaline in reaction and non-saline, low in available nitrogen, high in available phosphorous and available potassium, medium in organic carbon content with field capacity and Permanent wilting point of 21.7 and 9.60 per cent, respectively having available soil moisture of 76.50 mm in 0- 45 cm depth, the recommended dose of fertilizer 100-60-40 kg NPK ha^{-1}, entire dose of P and K was applied as basal before sowing and N applied as fertigation in 6 splits of equal doses at 10 days interval from 15 days after sowing (DAS). The experiment was conducted in a randomized block design with ten treatments of drip irrigation schedules *viz.,* drip irrigation at 0.6 ETc throughout the life (I_1), 0.8 Etc throughout the life (I_2), 1.0 Etc throughout the life (I_3), 1.2 ETc throughout the life (I_4), 0.6 ETc up to flowering 0.8 ETc later on (I_5), 0.6 ETc up to flowering 1.0 ETc later on (I_6), 0.6 ETc up to flowering 1.2 ETc later on (I_7), 0.8 ETc up to flowering 1.0 ETc later on (I_8), 0.8 ETc up to flowering 1.2 ETc later on (I_9), one surface furrow irrigation at 0.8 IW/CPE ratio (I_{10}) and replicated thrice. The data was analyzed statistically and N, P and K were estimated by following standard procedures. Sorghum was shown on October 2014 adopting a spacing of 0.40 m between rows and 0.15 m between plants to mean population of 1,66,666 plants ha^{-1}. Irrigation was scheduled based on USWB class a pan evaporation rates by estimating ETc by adopting suitable pan coefficient based on daily wind speed and relative humidity and crop coefficient as per crop stage as per FAO [2].

Results and Discussions

Number of grains panicle^{-1}, ear head length and ear head weight of *rabi* sorghum was significantly higher with 1.2 ETc drip irrigation schedule was on par with 0.6 or 0.8 ETc up to flowering and 1.2 ETc later on [Table-1]. Significantly lower yield attributes recorded with drip irrigation scheduled at estimated ETc of 0.6. Surface furrow irrigation at 0.8 IW/CPE ratio recorded on par ear head length with drip irrigation at 0.6 ETc throughout the life, 0.6 ETc up to flowering and 0.8 ETc or 1.0 ETc later on and was significantly lower than rest of the drip irrigation treatments.

No. of grains with furrow irrigation recorded Surface furrow irrigation recorded significantly lower compared to drip irrigation 1.2 ETc throughout the life, 0.6 or 0.8 ETc up to flowering and 1.2 ETc later on, though significantly higher than 0.6 ETc and on par with rest of the drip irrigation treatments. Surface furrow irrigation recorded significantly lower grains panicle^{-1} compared to other drip irrigation scheduling treatments of estimated 1.2 ETc throughout the life and estimated 0.6 or 0.8 ETc up to flowering and 1.2 ETc later on though significantly higher than 0.6 ETc throughout the life was on par with rest of the drip irrigation treatments. Significantly lower in ear head weight recorded with surface furrow irrigation at 0.8 IW/CPE ratio compared to all drip irrigation scheduling treatments except drip irrigation at 0.6 ETc up to flowering and 0.8 ETc later on and 0.6 ETc throughout the life and was significantly higher than drip irrigation with 0.6 ETc. Similar findings also reported [6], [11] in maize crop, [7] and [13] in sorghum crop.

The yield plant^{-1} of *rabi* sorghum realized with irrigation scheduled at estimated 1.2 Etc throughout the life was significantly higher than rest of the drip irrigation treatments except 0.8 ETc up to flowering and 1.2 ETc later on and drip irrigation scheduled at 0.6 ETcthroughout the life resulted in significantly loweryield plant^{-1} than rest of the treatments [Table-1]. Surface furrow irrigation at 0.8 IW/CPE ratio was significantly lower yield plant^{-1} compared to rest of the drip irrigation scheduling treatments except with drip irrigation at estimated 0.8 ETc throughout the life, 0.6 ETc up to flowering 0.8 or 1.0 ETc later on and significantly higher than drip irrigation at estimated 0.6 ETc throughout the life.

Table-1 *Yield attributes of rabi sorghum as influenced by different drip irrigation treatments*

Treatment	Ear head length(cm)	Ear head weight (g plant^{-1})	No. of grains plant^{-1}	Test weight (g)	Yield plant^{-1} (g plant^{-1})
I_1 - Drip Irrigation at estimated 0.6 ETc throughout the life	24.5	69.4	5833	31.6	38.0
I_2 - Drip Irrigation at estimated 0.8 ETc throughout the life	27.7	88.3	7499	33.7	55.1
I_3 - Drip Irrigation at estimated 1.0 ETc throughout the life	30.2	98.2	7993	34.6	65.5
I_4 - Drip Irrigation at estimated 1.2 ETc throughout the life	32.4	108.2	9076	37.1	76.1
I_5 - Drip Irrigation at estimated 0.6 ETc up to flowering and 0.8 ETc later on	25.0	74.4	7014	34.1	50.9
I_6 - Drip Irrigation at estimated 0.6 ETc up to flowering and 1.0 ETc later on	26.3	92.7	7838	34.7	58.7
I_7 - Drip Irrigation at estimated 0.6 ETc up to flowering and 1.2 ETc later on	31.0	100.7	8729	36.2	66.0
I_8 - Drip Irrigation at estimated 0.8 ETc up to flowering and 1.0 ETc later on	30.1	99.0	8432	36.1	65.9
I_9- Drip Irrigation at estimated 0.8 ETc up to flowering and 1.2 ETc later on	31.7	103.1	8997	36.6	74.2
I_{10}- Surface furrow irrigation at 0.8 IW/CPE ratio with irrigation water of 50 mm	25.2	79.9	7404	34.2	51.8
Mean	28.4	91.4	7881	34.9	60.2
SEm ±	0.73	2.7	348.6	0.9	2.4
CD (P= 0.05)	2.2	8.1	1036	2.5	7.1
CV (%)	4.5	5.2	7.7	4.2	6.9

Higher test weight of *rabi* sorghum was recorded with drip irrigation scheduled at 1.2 ETc which was significantly superior than drip irrigation scheduled at 0.6 ETc or 0.8 ETc throughout the life, 0.6 Etc up to flowering and 0.8 ETc later on and surface furrow irrigation at 0.8 IW/CPE and was on par with rest of the treatments.Significantly lowertest weight observed in irrigation scheduled at 0.6 Etc throughout the life over rest of the treatments except drip irrigation at estimated at 0.8 ETc throughout the life and 0.6 ETc up to flowering and at 0.8 ETc later on.

Sorghum grain yield realized during *rabi* with drip irrigation scheduled estimated at 1.2 ETc throughout the life was higher (8464 kg ha^{-1}) and differed significantly with rest of the drip irrigation treatments except with grain yield obtained at 1.0 ETc throughout the life, deficit irrigation 0.6 ETc up to flowering and 1.2 ETc later on, 0.8 ETc up to flowering and 1.0 ETc or 1.2 ETc later on irrigation schedules [Table-2]. There was an increase of 101.1 per cent yield with 1.2 ETc throughout life over 0.6 ETc throughout the life. Wherein, the grain yield realized at 1.0 ETc throughout the life, 0.6 ETc up to flowering then followed by 1.2 ETc, 0.8 ETc up to flowering and 1.0 ETc or 1.2 ETc later on drip irrigation scheduling were found to be at par with the yield obtained with irrigation scheduled at 1.2 ETc throughout the life irrigation schedule. This might be due to maintaining adequate soil moisture in the root zone depth throughout the crop growth period which facilitated in better uptake of water and nutrients having beneficial effect on growth viz., plant height and LAI which favored more production and translocation of photosynthates to the sink there by high dry matter production and yield contributing factors *viz.,* ear head weight, ear head length, no. of grains ear head^{-1} and test weight resulted in higher grain yield. Similar findings were also reported by [7] and [6], [11], and [8] in maize crop. Significantly lower grain yield was observed with deficit drip irrigation scheduled at 0.6 ETc throughout the life (4209 kg ha^{-1}) over rest of the treatments might be due to moisture stress leading to reduced test weight, grain weight, ear head weight and no. of grains ear head^{-1} [9] and in maize crop similar findings was reported by [14]. The reduction in yield was to the extent of 50.3 per cent in drip irrigation at 0.6 ETc compared to 1.2 ETc throughout the life. Whereas the sorghum grain yield obtained under surface furrow irrigation at 0.8 IW/CPE ratio was on par with drip irrigation at 0.8 ETc, 0.6 ETc up to flowering and 0.8 or 1.0 ETc later on and was significantly lower (6318 kg ha^{-1}) than rest of the drip irrigation treatments. Surface furrow irrigation at 0.8 IW/CPE ratio yield decrease was observed 25.4 per cent compared to 1.2 ETc throughout the life and 23.6 per cent compared to 0.8 ETc up to flowering and 1.2 ETc later on. It might be due to moisture fluctuation from field capacity to permanent wilting point in surface furrow irrigation while in drip irrigation moisture was maintained at field capacity level.

Stover yield of sorghum (8376 kg ha^{-1}) with estimated 1.2 ETc throughout the life drip irrigation schedule and it was on par with 0.8 ETc or 1.0 ETc throughout the life, 0.6 ETc up to and 1.0 ETc or 1.2 ETc later on, 0.6 or 0.8 ETc up to and 1.0 ETc or 1.2 ETc later on and significantly superior than rest of the treatments [Table-2]. This could be attributed to better vegetative growth, more dry matter production and biological yield under more favoured soil moisture availability [12], [3], [15] as compared to less frequency irrigation scheduling treatments. While deficit drip irrigation scheduled at 0.6 ETc throughout the life resulted in significantly the lower straw yield (5412 kg ha^{-1}) than rest of the treatments except with deficit drip irrigation at 0.6 ETc up to flowering and 0.8 ETc later on and surface furrow irrigation at 0.8 IW/ CPE ratio, because of moisture stress which showed in retarded growth, hastened senescence and quick drying of leaves there by reducing photosynthetically active surface area and consequently low biomass production. Whereas the surface furrow irrigation at 0.8 IW/CPE ratio recorded significantly lower straw yield (6318 kg ha^{-1}) compared to drip irrigation scheduling treatments of 1.2 ETc throughout the life and 0.8 ETc up to flowering and 1.0 or 1.2 ETc later on and was on par with drip irrigation schedules. It might be due to moisture fluctuation in furrow irrigation compared to drip irrigation treatments. Similar results reported by [8] in maize crop.

Significantly, higher biological yield of *rabi* sorghum (16840 kg ha^{-1}) was obtained at estimated ETc of 1.2 throughout the life treatment over drip irrigation at 0.6 ETc up to flowering and 0.8 or 1.0 ETc later on, 0.6 or 0.8 ETc throughout the life and surface furrow irrigation 0.8 IW/CPE ratio and was on par with drip irrigation at 0.8 ETc up to flowering and 1.0 or 1.2 ETc later on, 0.6 ETc up to flowering and 1.2 ETc later on and 1.0 ETc throughout the life treatment [Table-2]. This could be attributed to under more favoured soil moisture availability better vegetative growth; more dry matter production resulted in higher biological yield [10] and [5]. Biological yield recorded with drip irrigation at estimated 0.6 ETc throughout the life was (9621 kg ha^{-1}) on par with 0.6 ETc up to flowering and 0.8 ETc later treatments and was significantly lower than rest of the treatments. Biological yield of *rabi* sorghum obtained under surface furrow irrigation 0.8 or 0.8 IW/CPE ratio (12636 kg ha^{-1}) was on par with 0.6 ETc up to flowering and 1.0 ETc later on and 0.8 ETc throughout the life and was significantly higher than drip irrigation 0.6 ETc throughout the life treatment, though significantly lower than rest of the treatments. It may be due to moisture fluctuation in surface furrow irrigation resulted in lower biological yield compared to drip irrigation treatments.

Table-2 *Grain, stover, biological yield and harvest index (%) of rabi sorghum as influenced by different drip irrigation treatments*

Treatment	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	Irrigation water applied (mm)
I_1 - Drip Irrigation at estimated 0.6 ETc throughout the life	4209	5412	9621	43.6	195.7
I_2 - Drip Irrigation at estimated 0.8 ETc throughout the life	6906	7155	14061	49.0	233.0
I_3 - Drip Irrigation at estimated 1.0 ETcthroughout the life	7738	7550	15288	50.6	270.5
I_4 - Drip Irrigation at estimated 1.2 ETc throughout the life	8464	8376	16840	50.3	308.6
I_5 - Drip Irrigation at estimated 0.6 ETc up to flowering and 0.8 ETc later on	5364	5677	11041	48.6	218.7
I_6 - Drip Irrigation at estimated 0.6 ETcup to flowering and 1.0 ETc later on	6464	7327	13792	47.1	241.7
I_7 - Drip Irrigation at estimated 0.6 ETc up to flowering and 1.2 ETc later on	7887	7589	15476	51.0	264.7
I_8 - Drip Irrigation at estimated 0.8 ETc up to flowering and 1.0 ETc later on	7870	7926	15795	50.0	256.0
I_9- Drip Irrigation at estimated 0.8 ETc up to flowering and 1.2 ETc later on	8233	8226	16459	50.1	279.0
I_{10}- Surface furrow irrigation at 0.8 IW/CPE ratio with irrigation water of 50 mm	6318	6318	12636	49.8	331.3
Mean	6945	7155	14101	49.0	259.9
SEm ±	325	424	561	1.7	
CD (P= 0.05)	965	1260	1664	NS	
CV %	8.1	10.3	6.9	6.1	

There was no significant difference between different drip irrigation treatments regarding harvest index of *rabi* sorghum. However, the harvest index was ranged from 43.6 per cent (drip irrigation at estimated 0.6 ETc throughout the life) and 51.0 per cent (drip irrigation 0.6 ETc up to flowering and 1.2 ETc later on) with mean of 49.0 per cent. Similar findings also reported by [1] in maize crop.

Conclusion

Drip irrigation with 1.2 ETc throughout the life recorded higher yield attributes and yields compared to other drip irrigation treatments and surface furrow irrigation at 0.8 IW/CPE ratio with irrigation of 50 mm. Under deficit irrigation conditions, drip irrigation at 0.8 ETc up to flowering and 1.0 or 1.2 ETc later followed by 0.6 ETc up to flowering and 1.2 ETc later on can be recommended over the drip irrigation 1.0 to 1.2 ETc throughout the life with minimum reduction in yield.

Conflict of Interest: None declared

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