**Effect of sowing dates and irrigation schedules on yield attributing characters and yield of *Rabi* Sorghum (*Sorghum bicolor* (L.) Moench)**

**ABSTRACT**

A field experiment was carried out during winter (*rabi*) season 2022-23 on sandy loam soils at the experimental farm of ICAR-Indian Institute of Millets Research, Rajendranagar, Hyderabad. The investigation aimed to evaluate the effect of sowing dates and irrigation schedules on growth, yield and WUE of rabi sorghum. The experiment was laid in a split plot design with twelve treatments replicated thrice. The main plot treatments include irrigation schedules i.e., life-saving irrigation (I1), irrigation at 50%DASM (I2), irrigation at critical growth stages (tillering, booting, anthesis, grain filling) (I3) and different sowing periods as subplot treatments i.e., sowing on 15th September (D1), 30th September (D2), 15th October (D3) and 30th October (D4). The results revealed that the effect of D2 sowing on 30th September recorded highest growth and yield and among irrigation schedules I3 recorded the highest growth and yield.

**Key words**: sowing dates, irrigation schedules, yield attributes, yield and *Rabi* sorghum

**1. Introduction**

Sorghum (*Sorghum bicolor* (L.) Moench) is the fifth most important cereal crop and its importance is ever increasing as it is the source of staple food for poor people, feed for poultry and piggery. In India it occupies 4.1 million hectares with a production of 3.5 million tones and productivity of 849 kg/ha. In Telangana Sorghum is grown in an area of 52,882 acres (Department of Agriculture, Telangana, 2021). It is the second cheapest source of energy and micronutrients after pearl millet and majority of central India depend on sorghum for their dietary and energy requirements (Parthasarathy Rao *et* *al*., 2006). Sorghum plant is nutritious fodder for dairy animals which is used as both dry and green fodder. Grains are also used in production of alcoholic beverages and biodiesel. Sorghum is a rich source of carbohydrates, proteins, minerals and vitamin B1 and B2 (Bender and Bender 2005). Sorghum is grown under the rainfed as well as irrigated conditions in most of the major states. Although sorghum has great importance and considerable area under *rabi* sorghum its productivity is very low due to some factors like use of local low yielding varieties, low adoption of improved technology, untimely sowing, weather variables, erratic distribution of monsoons and over exploitation of ground water etc. Limited and erratic rainfall in rainfed area creates moisture stress during the various critical stages of crop life result in severe yield reduction. Among the various agronomic practices, sowing time is the most important factor which vary based on region and variety. Sowing time is the considerable yield contributing factor in *rabi* sorghum because it determines temperature and photo period along with soil moisture (Biradar and Gollagi, 2006). Hence the present investigation was conducted to find out the suitable irrigation schedules and proper sowing time for improving the productivity of *rabi* sorghum.

**2. 1MATERIALS AND METHODS**

A field experiment was conducted during *rabi* season in 2022-23 at ICAR-Indian Institute of Millets Research, Rajendranagar Hyderabad. The farm is situated at an altitude of 476.5 meters above mean sea level, 170 04' N latitude and 750 54' E longitude. The average maximum and minimum atmospheric temperatures were 30.10C and 17.00C respectively. The average relative humidity was 86% in the morning and 47% in the evening. Rainfall received during the crop period in 2022-23 is 330.8 mm. The soil of experimental field was fairly levelled and sandy loam in texture, low in available N 145.9 kg/ha, medium in P2O5 10.46 kg/ha and high in K2O 216.8 kg/ha, low in organic carbon content (0.168%). The experiment was conducted in Split Plot Design replicated three times which consisted of three irrigation schedules as main plot treatments, four sowing dates as subplot treatments. The main plot treatments comprise irrigation schedules viz., life-saving irrigation (I1), irrigation at 50% DASM (I2), irrigation at critical crop growth stages (I3) and subplot treatments comprise four sowing dates viz., sowing on 15th September (D1), 30th September (D2), 15th October (D3) and 30th October (D4). Sorghum variety M35-1 was sown with spacing of 45×15 cm. The recommended dose of fertilizer (80:40:40 kg NPK ha-1) was applied to crop. All the other inter cultivation operations and plant protection measures were practiced regularly. After harvest grain yield and stover yields kg/ha were recorded.

**3. RESULTS AND DISCUSSION**

***3.1 Yield attributes***

***3.1.1 Number of panicles m-2***

The effect of irrigation schedules was pronounced in producing number of productive tillers. Maximum number of panicles m-2 were observed in 13 (irrigation at critical stages) (12.2) and was statistically on par with I2 (11.9). Significantly less number of panicles m-2 (11.6) were observed in I1 (life-saving irrigation) due to less number of irrigations. Increasing the irrigation water might be attributed to the beneficial effect of irrigation on growth and photosynthetic capacity. Consequently, more dry matter accumulated in yield components, and led to increase in number of panicles m-2. Similar results were observed by Salem, 2015. Among different sowing dates, 15th September sown crop gave significantly increase in number of panicles m-2 (12.7) and significantly superior over S2 (30th September) (12.3), S3 (15th October) (11.7) and the lowest number of panicles m-2 were observed in S4 (10.7) *i.e.,* 30th October sown crop. As sowing was delayed, the evaporation losses increased and the crop suffered from moisture stress which led to decrease in number of panicles m-2. Interaction effect between irrigation schedules and sowing dates was significant for number of panicles m-2. Significantly increase in number of panicles m-2 (13.1) were observed in I3S1, which was due to availability of sufficient moisture and favorable weather conditions while less number of paniclesm-2 (10.3) were found in I1S4.

***3.1.2 Number of grains panicle-1***

Number of grains panicle-1 showed significant difference with irrigation scheduling practices. Application of irrigation at critical stages of crop growth recorded significantly highest number of grains panicle-1 (1540) which was statistically similar with application of irrigation at 50% DASM (1534). Significantly lower number of grains panicle-1 (1465) were recorded with life-saving irrigation treatment. This may be due to the reduction in number of irrigations. As number of irrigations reduced, evaporation losses became more and the available soil moisture was also reduced ultimately led to reduction in number of grains panicle-1. Similar results were reported by Mubarik *et al*. (2022). There was a significant variation in number of grains panicle-1 among sowing dates. Sowing on 15th September had recorded significantly increase in number of grains panicle-1 (1762) which was superior over other sowing dates. Significantly decrease in number of grains panicle-1 (1130) were recorded in S4 (sowing on 30th October). This might be due to the low temperatures which resulted in pollen sterility and led to the reduction in grain filling of the sorghum (Taylor, 1973). The interaction effect of irrigation schedules and sowing dates was shown significant influence on number of panicles. Less number of grains per panicle (986) were recorded in I1S4 and higher number of grains per panicle (1848) were recorded in I3S1. These results may be due to favorable temperatures and good moisture availability which resulted in high photosynthetic assimilation and a greater number of grains. Maulana and Tesso (2013) documented a

**Table.1** Yield attributing characters of *rabi* sorghum influenced by irrigation schedules and sowing dates

|  |  |  |  |
| --- | --- | --- | --- |
| Treatments | No of panicles  m-2 | No of grains panicle-1 | Test weight  (g) |
| Irrigation schedules | | | |
| I1: Life-saving irrigation | 11.6 | 1415 | 34.9 |
| I2: Irrigation at 50% DASM | 11.9 | 1534 | 35.4 |
| I3: Irrigation at critical growth stages | 12.2 | 1540 | 35.6 |
| SEm± | 0.1 | 20.4 | 0.5 |
| C.D.(P=0.05) | 0.3 | 79.2 | NS |
| Sowing dates | | | |
| S1: 15 Sep | 12.7 | 1762 | 36.1 |
| S2: 30 Sep | 12.3 | 1609 | 35.6 |
| S3: 15 oct | 11.7 | 1484 | 35.1 |
| S4: 30 Oct | 10.7 | 1131 | 34.4 |
| SEm± | 0.1 | 21.7 | 0.4 |
| C.D.(P=0.05) | 0.2 | 64.5 | NS |
| **Interaction** | | | |
| **Sub treatment at same level of main treatment** | | | |
| SEm (±) | 0.2 | 41.2 | 1.0 |
| CD (p=0.05) | 0.6 | 133.8 | NS |
| **Main treatment at same level of sub treatment** | | | |
| SEm (±) | 0.1 | 34.8 | 0.7 |
| CD (p=0.05) | 0.4 | 103.6 | NS |

**Table 1a.** Number of panicles m-2 of *rabi* sorghum as influenced by interaction effect of irrigation schedules and sowing dates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Number of panicles m-2** | | | | |
| **Treatments** | **S1** | **S2** | **S3** | **S4** | **Mean** |
| **I1** | 12.1 | 12.1 | 11.7 | 10.3 | 11.6 |
| **I2** | 12.9 | 12.2 | 11.7 | 10.6 | 11.9 |
| **I3** | 13.1 | 12.6 | 11.8 | 11.2 | 12.2 |
| **Mean** | 12.7 | 12.3 | 11.7 | 10.7 | 11.9 |
| **Factors** | | **SEm (±)** | | **CD (p=0.05)** | |
| Main (I) | | 0.1 | | 0.3 | |
| Sub (S) | | 0.1 | | 0.2 | |
| Sub (S) at same main (I) | | 0.2 | | 0.6 | |
| Main (I) at same or different sub (S) | | 0.1 | | 0.4 | |

**Table 1b.** Number of grains panicle-1 of *rabi* sorghum as influenced by interaction effect of irrigation schedules and sowing dates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Number of grains panicle-1** | | | | |
| **Treatments** | **S1** | **Treatments** | **S1** | **Treatments** | **S1** |
| **I1** | 1679 | **I1** | 1679 | **I1** | 1679 |
| **I2** | 1759 | **I2** | 1759 | **I2** | 1759 |
| **I3** | 1848 | **I3** | 1848 | **I3** | 1848 |
| **Mean** | 1762 | **Mean** | 1762 | **Mean** | 1762 |
| **Factors** | | **SEm (±)** | | **Factors** | |
| Main (I) | | 20.4 | | Main (I) | |
| Sub (S) | | 21.7 | | Sub (S) | |
| Sub (S) at same main (I) | | 41.2 | | Sub (S) at same main (I) | |
| Main (I) at same or different sub (S) | | 34.8 | | Main (I) at same or different sub (S) | |

noteworthy reduction in the number of grains per panicle and reported that 388 grains per panicle were recorded when the crop experienced cold temperature stress during the flowering and pollination stages. This was in stark contrast to the 846 grains per panicle recorded under normal temperature conditions. The decrease in seed production in instances of late sowing was attributed to a diminished production of photosynthates due to the water stress. These findings align with the results reported by Chaithra *et al*. (2018).

***3.1.3 Test weight (g)***

The perusal of data on test weight as affected by irrigation schedules and sowing dates was analysed and presented in Table 1. Test weight was not significantly influenced by irrigation schedules and sowing dates. The interaction effect was also found to be non-significant. An increase in 1000 seed weight (35.6 g) was observed in irrigation at critical stages of crop growth. Among sowing dates, an increase in test weight (36.1 g) was observed in S1 (sowing on 15th September) when compared to other sowing dates.

***3.2 Yield***

***3.2.1 Grain Yield***

Grain yield was found to be significant among the irrigation schedules and sowing windows. Among different irrigation treatments, significantly higher grain yield was recorded in I3 (irrigation at critical crop growth stages) (2734 kg/ha) while lowest grain yield was obtained in I1 (life-saving irrigation) (2251 kg/ha) this was due to the water stress (Table.2). Grain yield is a function of all the yield attributes like number of panicles per plant, number of grains per panicle and test weight. The lowest grain yield was recorded when only one life-saving irrigation was given. This decrease in yield was attributed to one life saving irrigation. When water supply was decreased (only life-saving irrigation), the photosynthetic assimilation and transportation to the sink was reduced which resulted in a significant decline in both growth and yield parameters and led to a reduction in sorghum grain yield. Similar findings were reported by Sepaskhah and Ghasemi (2008), Ibrahim *et al*. (2013) and Pradhan *et al*. (2015). The difference in grain yield of sorghum was conspicuous with different sowing dates. The highest grain yield (2872 kg ha-1) was obtained in crop sown on 15th September which is superior over the other sowings. The lowest grain yield (1955 kg ha-1) was recorded in 30th October sown crop.The lowest grain yield in delayed sowing was due to low temperatures at flowering and fail pollination process which might have led to pollen sterility. Taylor 1973 has reported that the poor grain yield was caused due to low temperatures and pollen sterility. These were supported by Reddy *et al*. (2007) and Hulihalli *et al*. (2016). The early sown crop enjoyed favorable weather conditions, temperature and produce high dry matter production, a greater number of effective tillers, number of panicles and number of grains per panicle ultimately it led to higher grain yield (Mubarik *et al*., 2022). The interaction effect of irrigation schedules and sowing dates had shown significant effect on grain yield of *rabi* sorghum. Higher grain yield was obtained in I3S1 treatment combination (3000 kg ha-1). Whereas the lowest grain yield was obtained in I1S4 treatment combination (1401 kg ha-1). Grain yield was less when only life-saving irrigation was applied. This might be due to less times of irrigations, more evaporation losses which led to reduction in the availability of soil moisture which was utilised by the crop for its physiological activities. This reduces the number of panicles m-2 and number of grains which automatically reduced yield. The reduced grain count per panicle in late sowing was attributed to the limited production of photosynthates resulting from the shorter growing season. These findings were aligned with those documented by Haider in 2004. The early sowing resulted in better development of grains due to longer growing period. Similar findings were reported by Spink *et al*. (2000) and Shahzad *et al*. (2002). Early sowing led to an increased grain yield by establishing early ground cover, effectively harnessing available precipitation and soil moisture, and enhancing the probability of favorable outcomes in terms of grain yield and its constituent components. The growth and development of crops are profoundly influenced by environmental factors such as temperature, radiation, and photoperiod.

**Table 2.** Grain, stover and harvest index of *rabi* sorghum as influenced by irrigation schedules and sowing dates

|  |  |  |  |
| --- | --- | --- | --- |
| Treatments | Grain yield (kg/ha) | Stover yield (kg/ha) | Harvest index (%) |
| **Irrigation schedules** | | | |
| I1: Life-saving irrigation | 2251 | 6778 | 24.5 |
| I2: Irrigation at 50% DASM | 2380 | 7120 | 25.0 |
| I3: Irrigation at critical growth stages | 2734 | 7829 | 26.8 |
| **SEm±** | 76.93 | 155.0 | 0.41 |
| **C.D.(P=0.05)** | 302.2 | 608.7 | 1.64 |
| **Sowing dates** | | | |
| S1: 15 Sep | 2375 | 6703.98 | 25.0 |
| S2: 30 Sep | 2872 | 8696.36 | 25.8 |
| S3: 15 oct | 2592 | 7627.7 | 25.4 |
| S4: 30 Oct | 1955 | 5941.54 | 24.8 |
| **SEm±** | 47.76 | 96.85 | 0.50 |
| **C.D.(P=0.05)** | 141.90 | 287.75 | 1.49 |
| **Interaction** | | | |
| **Sub treatment at same level of main treatment** | | | |
| S.Em (±) | 72.3 | 155.6 | 1.0 |
| CD (p=0.05) | 218.9 | NS | NS |
| **Main treatment at same level of sub treatment** | | | |
| SEm (±) | 70.1 | 134.5 | 0.9 |
| CD (p=0.05) | 208.1 | NS | NS |

**Table 2a.**Grain yield of *rabi* sorghum as influenced by interaction effect of irrigation schedules and sowing dates

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Grain yield (kg ha-1)** | | | | |
| **Treatments** | **S1** | **S2** | **S3** | **S4** | **Mean** |
| **I1** | 2660 | 2249 | 1785 | 1401 | 2024 |
| **I2** | 2744 | 2433 | 2024 | 1851 | 2263 |
| **I3** | 3000 | 2773 | 2581 | 2037 | 2598 |
| **Mean** | 2801 | 2485 | 2130 | 1763 | 2295 |
| **Factors** | | **SEm (±)** | | **CD (p=0.05)** | |
| Main (I) | | 15.5 | | 60.6 | |
| Sub (S) | | 40.4 | | 120.1 | |
| Sub (S) at same main (I) | | 72.3 | | 218.9 | |
| Main (I) at same or different sub (S) | | 70.1 | | 208.1 | |

*Stover yield*

Stover yield shown a significant difference in yield by different irrigation treatments. Among different irrigation treatments, I3-irrigation at critical crop growth stages (3952 kg ha-1) had recorded significantly higher stover yield compared to I2 (Irrigation at 50% DASM) (3734 kgha-1) and I1 (Life-saving irrigation) (3544 kg ha-1). The increase in stover yield when irrigations were scheduled at critical stages might be due to sufficient soil moisture, nutrient uptake and better translocation of nutrients with a greater number of irrigations when compared to other irrigation treatments. Similar results were found by Chaitanya *et al*., 2017. The difference in stover yield of sorghum was conspicuous with different sowing dates. The highest stover yield (4183 kg ha-1) was obtained in crop sown on 15th September which was superior over the other sowings. The lowest stover yield (3269 kg ha-1) was recorded in S4 sowing on 30th October. In early sowing favorable weather conditions resulted in a rapid cell division and increase in growth attributes. Secondly, better utilization of available resources, precipitation and soil moisture contributed to increased straw yield. Similar results were recorded by Hulihalli *et* *al*., 2016. The early sown crop enjoyed the favorable weather conditions and temperature optimum for the crop which reflects into better crop growth. Similar results were found by Desai *et al*. (2015). Interaction effect of irrigation schedules and sowing dates did not exert any significant effect on stover yield.

*Harvest index*

Harvest index of sorghum was maximum (26.8%) when irrigation was given at critical crop growth stages. Among different dates of sowing the crop sown on 30th September given higher harvest index (25.8%) and the lowest harvest index was recorded in 30th October (24.8%).

**4. CONCLUSION**

It can be concluded from the present investigation that irrigation at critical *Sorghum bicolor* growth stages is the best suitable irrigation schedule and sowing on 30th September produced higher seed yield, stover yield and harvest index in *rabi* sorghum.

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