Original Research Article

Growth, yield and water use efficiency of sweet sorghum[*Sorghum bicolor* (L.) Moench]affected by drip irrigation and nitrogen levels through fertigation

Abstract:

An experiment entitled **"Growth, yield and water use efficiency of sweet sorghum [*Sorghum bicolor* (L.) Moench] affected by drip irrigation and nitrogen levels through fertigation"**was carried out on clayey and slightly alkaline soil during *rabi*season of 2019-20 and 2020-21 at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh. The experiment was laid out in split plot design with four replications. There were nine treatment combinations. The main plot treatments *viz;* (I_1) drip irrigation at 0.6 PEF, (I_2) drip irrigation at 0.8 PEF and (I_3) drip irrigation at 1.0 PEF; and sub plot consist of three nitrogen fertigation levels *viz;* (N_1) 75% RDN through fertigation, (N_2) 100% RDN through fertigation and (N_3) 125% RDN through fertigation (RDF for sweet sorghum is 90-40-40 N, P_2O_5 and K_2O kg ha^{-1}). The results revealed that drip irrigation scheduling at 1.0 PEF enhance consumptive use of water and nitrogen use efficiency which ultimately resulted in higher grain and fodder yields of sweet sorghum.The results indicated that 125% RDN through fertigation significantly increased water useefficiency, which eventually recorded higher grain and fodder yields of sweet sorghum. Recommendation and significance of this study

Key words: Sweet sorghum, drip irrigation, nitrogen, fertigation and water use efficiency

1. INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) can be classified as sweet, grain and forage types.Sweet sorghum can grow almost everywhere where, grain sorghum is grown and is now found in a number of developing and industrialized countries.The plant looks much like grain sorghum, except, that it is often taller (sometimes much taller, reaching up to 4 meters) and it accumulates a great deal of sugary juice in the stalk that can be used for a variety of uses such as food, feed, fodder, fuel and tuber benefiting the sobriquet "Smart crop". Besides having rapid growth, high sugar accumulation and biomass production potential, sweet sorghum has wider adaptability (Reddy *et al*., 2005).Sweet sorghum usually is planted for sugar (Almodares, 1996) and ethanol production (Gnansounoua*et al.*, 2005) and (Almodares, 2009).Thus, development of sweet sorghum will play an important role in promoting the development of agricultural production, livestock husbandry (Fazaeli *et al.*, 2006) too old citation, energy sources (biofuel) (Nahvi *et al.*, 1994), too old citation refining sugar, paper making,bedding, roofing, fencing and chewing etc. Sweet sorghum requires one fourth amount of water than that required for sugarcane. The plant matures between 115-125 days after plantation. It can be harvested three times in a year.

Indian farmers mostly use surface irrigation for growing crops which is mainly responsible for the low water use efficiency and productivity. Sweet sorghum require less fertilizer and water intake, possibility of multiple cropping per year, it is resilient to able to grow on marginal area especially drought prone area, has ratoon capability, wide geographic adaptability (Ananda *et al.*, 2011), (Andrzejewski*et al.*, 2013) and (Agung*et al.*, 2013). Practicing deficit irrigation through drip system could increase the irrigated area with increased yield and quality. By introducing drip with fertigation, it is possible to increase the yield of crops by 3 times from the same quantity of water. There was an increase in the use efficiency of nitrogen, phosphorus and potassium to 95, 45 and 80 per cent, respectively (Satisha, 1997). Too old citation When fertilizer is applied through the drip, it is observed that besides the yield increase of about 30 per cent of the fertilizer could be saved (Sivanappan and Ranghaswami, 2005). Drip irrigation can achieve 90-95 per cent efficiency by reducing evaporation and deep percolation.

It is important to determine the optimal N applicationrate needed to achieve the maximum yield and nitrogenuse efficiency (NUE). Many studies have investigated theeffects of N application on crop growth, yield andN utilization, especially over single-cropping seasons. Ingeneral, reasonable fertilization improves crop growthand yield, but overfertilization can harm plants and lowerNUE (Dai*et al.*, 2015; Yan*et al.*, 2015). Water supply alsoinfluences fertilizer utilization. Under irrigated conditions,N applications promote the growth and development of crops and the optimum N rate is a stable value. However,in rainfed areas, the optimal N application rate is affectedby rainfall (Quemada and Gabriel, 2016). In these areas,N applications promote crop growth, but can also result ina large amount of unused N remaining in the soil(Ju*et al.*, 2006; Ju and Christie, 2011; Dai*et al.*, 2015). Inaddition, soil water consumption is more intense and canlead to lower soil water content during the mature plantstage (Wang*et al.*, 2018 andQiang*et al.*, 2019).

In India, there is ample scope to grow *rabi* sweet sorghum under irrigated conditions with considerably higher productivity. The information available on drip irrigation and nitrogen levels through fertigation especially in sweet sorghum is very scare undersouthwest India in particular. At present there is practically no systemic research work has been carried out on drip irrigation and nitrogen levels through fertigationfor *rabi* sweet sorghum in this region. Taking note of the facts highlighted above, the present investigation was conducted during *rabi*season of 2019-20 and 2020-21 with following objectives. (1) To study the effect of drip irrigation on growth and yield of sweet sorghum (2) To find out the effect of nitrogen fertigation levels on growth and yield of sweet sorghum (3) To determine the effect of drip irrigation and nitrogen fertigation levels on consumptive use of water, water use efficiency and fertilizer use efficiency and(4) To study the interaction effect of drip irrigation and nitrogen fertigation levels on growth, yield and quality of sweet sorghum if any.

2. MATERIALS AND METHODS

2.1 Description of the study area

2.2 Research design

2.3 Data analysis

The field trials were conducted during *rabi* 2019-20 and 2020-21at Junagadh Agricultural University(21^{o}31’N latitudes and 70^{o}33’E longitudes, 83 m MSL) in Junagadh, Gujarat, India. The rainy season commences in the second fortnight of June and ends by September with an average rainfall of 919.9 mm (average of last 10 years). Mean maximum and minimum temperature during the crop growth and development period of 2019-20 ranged between 25.4 to 34.3°C and 9.7 to 22.0°C, respectively. The range of mean morning and evening relative humidity, bright sun shine, wind speed and daily evaporation were 56 to 82% and 24 to 51%, 3.2 to 9.1 h, 2.2 to 4.9 km/h and 3.1-5.8 mm, respectively during the year 2019-20. While in year 2020-21, the mean maximum and minimum temperature during the crop growth and development period were ranged between 25.3 to 35.2°C and 9.5 to 18.7°C, respectively. The range of average mean morning and evening relative humidity, bright sun shine, wind speed and daily evaporation was 58 to 74% and 18 to 44%, 3.4 to 10.3 h, 1.9 to 7.3 km/h and 3.4 to 7.0 mm, respectively.Soil of the experimental plot was clayey in texture, medium in organic carbon (0.60 and 0.59% in 2019-20 and 2020-21, respectively) and slightly alkaline in reaction with pH 8.00 and 7.79, EC 0.47 and 0.34 dS m^{-1}. The soil was medium in available nitrogen (258.30 and 255.80 kg ha^{-1} 2019-20 and 2020-21, respectively), phosphorus (37.48 and 34.89 kg ha^{-1} in 2019-20 and 2020-21, respectively) and potash (225.60 and 205.00 kg ha^{-1} in 2019-20 and 2020-21, respectively).Open well water was the main source of irrigation.

The experiment comprising of nine treatment combinations and it was laid out in Split Plot Design (SPD) with four replications.The main plot treatments *viz.;* (I_1) drip irrigation at 0.6 PEF, (I_2) drip irrigation at 0.8 PEF and (I_3) drip irrigation at 1.0 PEF; and sub plot consist of three nitrogen fertigation levels *viz.;* (N_1) 75% RDN through fertigation, (N_2) 100% RDN through fertigation and (N_3) 125% RDN through fertigation (RDF for sweet sorghum is 90-40-40 N, P_2O_5 and K_2O kg ha^{-1}).Crop was irrigated by drip irrigation system.Lateral pipes with inline drippers spaced at 120 cm withdischarge rate of 4.0lph were used in the trial and they areplaced 50cm apart. Irrigation pressure was maintained at1.2 kg $cm^{-2}$to have adequate discharge from the drippers.Irrigation was given alternate days and fivefertigationswere given during entire cropping period starting from thirty five days after germination of crop at ten days interval.A first common irrigation of 50 mm depth was given after sowing in all the plots for uniform germination of the crop and second common irrigation of 50 mm depth was applied after one week of first common irrigation for proper establishment of crop. Total of 34irrigations through drip irrigation system were given duringthe cropping period of both the years.

Entire doses of Phosphorus and Potassium were applied in previously opened furrows just before sowing as basal application in form of single super phosphate (16% P) and muriate of potash (60% K), respectively and later furrows were covered with soil. Nitrogen was applied in the form of urea (46% N) through drip fertigation.The seeds of sweet sorghum variety CSV 24SS was used for sowing. The sowing of 15 kg ha^{-1} seeds were done at 4-5 cm deep in furrow of each plot in row at 10 cm spacing.After emergence of crop, gap filling and thinning operations were carried out to maintain intra row spacing and plant stand.All other agronomic practices were carried out for the all treatmentsuniformly.

Randomly selected five plants per treatment andreplication were tagged in the field for observation recordingfor plant height, dry matter accumulation $plant^{-1}$, grain yield and dry fodder yield at the time of harvest. Seed yield $plant^{-1}$was recorded and converted to seed yield per ha.

Water use efficiency values as kg ha^{-1} mm^{-1}ofirrigation water applied were calculated

$$\underset{(\text{kg ha}^{-1}\ \text{mm}^{-1})}{\text{WUE}} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Total quantity of irrigation water applied (mm)}} \quad \text{----- (1)}$$

for each treatmentafter harvest using equation (1) according to Condon and Hall (1913).

Nitrogen use efficiency values in kg grain $ha^{-1}$and dry fodder yield ha^{-1}nutrients were calculatedfor each treatment using equation (2) as suggested by Veeranna (2000).

$$\text{NUE } (\text{Kg kg}^{-1}) = \frac{\text{Yield (kg ha}^{-1})}{\text{Total quantity of nutrients applied (kg ha}^{-1})} \quad \text{----- (2)}$$

The data were subjected to statistical analysis by adopting appropriate analysis of variance as described by Gomez and Gomez (1984). Wherever the F values found significant at 5 per cent level of probability, the critical difference (CD at 5%) values were computed for making comparison among the treatment means.

3. RESULTS AND DISCUSSION

Separate results from discussion

3.1 Growth parameters:

The data regarding plant height at harvest (Table 1) showed that significantly maximum plant height of 219.7, 221.0 and 220.3 cm were recorded under drip irrigation scheduled at 1.0 PEF (I_3) during 2019-20, 2020-21 and in pooled results, respectively which was found statistically at par with drip irrigation scheduled at 0.8 PEF (I_2) during individual years and in pooled results. Significantly lower plant height of 182.1, 183.4 and 182.8 cm were noted under drip irrigation scheduled at 0.6 PEF (I_1) during 2019-20, 2020-21 and in pooled results, respectively.The response of different drip irrigation levels in terms of overall improvement in growth parameters is further supported by the fact that the higher irrigation frequency, increased the availability of nutrients and thus, enhanced the uptake of nutrients which consequently improved the growth of sweet sorghum. Similar results were observed by Mugalkhod (2005) in baby corn, Abdullah (2008), Basava (2012) and Patel *et al.* (2014) in sweet corn, Calvin and Messing (2012) and Qu *et al.* (2014) in sweet sorghum, Lakshmi *et al.* (2020) in sweet corn hybrid and Vinutha *et al.* (2021) in maize.The data presented in Table 2 indicated that there was a significant effect of drip irrigation schedules on dry matter accumulation $plant^{-1}$ at harvest during 2019-20, 2020-21 and in pooled results. Significantly the maximum dry matter $plant^{-1}$of 111.2, 130.3 and 120.7 $gplant^{-1}$ was recorded at harvest under drip irrigation scheduled at 1.0 PEF (I_3) during2019-20, 2020-21 and pooled results, respectively. However, it was remained at par with treatment I_2 (drip irrigation scheduled at 0.8 PEF) in 2019-20, 2020-21 and in pooled results. Whereas, significantly the lowest dry matter accumulation $plant^{-1}$ at harvest of 82.3, 101.3 and 91.8 gwas noted with drip irrigationscheduled at 0.6 PEF (I_1) during2019-20, 2020-21 and in pooled results, respectively.Scheduling drip irrigation at 1.0 PEF had significant improvement in dry matter plant^{-1} at different growth stages of sweet sorghum seems to an account of better vegetative growth which is well reflected by increase in plant height and length of internode. It is an established fact that the soil water deficiency inhibits leaf expansion and stem elongation in plants through its reduction of relative turgidity. Reduced water supply also causes closure of stomata which raises the plant temperatures consequently increases respiration leading to higher break down of assimilates and ultimately poor growth and reduced dry matter accumulation under lower drip irrigation at 0.6 PEF. Above ground biomass showed a sigmoidal growing trend, especially in irrigated treatments and it was affected by water availability as reported by Barbanti*et al.* (2006) and Cosentino*et al.* (2012) in sweet sorghum. Similar findings were also reported by Patel *et al.* (2000) in fennel, Rao *et al.* (2010) in cumin. The significant reduction in plant growth with decreased frequency of irrigation seems to be resultant effects of water stress, which might have reduced the availability and uptake of water and nutrients. The results are in close accordance with the findings of Viswanatha (1999), Abdullah (2008) and Basava (2012) in sweet corn, Mugalkhod (2005) in baby corn, Patel *et al.* (2012) in fennel, Padmaja (2014) and Brar*et al.* (2016) in maize.

The data (Table 1) clearly indicated that different nitrogen fertigation levels produced their significant effect on plant height at harvest. The higher plant height of 221.1, 223.6 and 222.4 cm were recorded when crop was fertilized with 125% RDN through drip fertigation during 2019-20, 2020-21 and in pooled results, respectively and it was remained at par with nitrogen fertigation level (N_2) during 2019-20, 2020-21 and in pooled results. Significantly lower plant height of 178.0, 178.6 and 178.3 cm were recorded when crop was fertilized with 75% RDN (N_1) through drip fertigation during individual years and in pooled results, respectively.Increase in nitrogen rate increased plant height that might have increased photosynthate formation and partitioning into stems that might have favourable impacts on plant height of sweet sorghum. The plant height increased with increasing fertigation level might be due to increased availability of nutrients, better uptake by the roots and increased in the number of internodes and inter nodal distance. This results are in harmony with those obtained by Taha*et al.* (1999), El-Zeny (2004), El-Shafai*et al.* (2005), Ismail *et al.* (2005) and Ismail *et al.* (2007) in sweet sorghum.It was revealed from the results presented in Table 2on dry matter accumulation plant^{-1} at harvest that different nitrogen fertigation levels produced their significant effect on dry matter accumulation plant^{-1}at harvest.The treatment N_3 (125% RDN through drip fertigation) recorded higher dry matter accumulation plant^{-1} of 107.1, 129.9 and 118.5 g plant^{-1} being at par with treatment N_2 (100% RDN) during the year 2019-20, 2020-21 and in pooled results, respectively. Thelowest dry matter accumulation plant^{-1}at harvest of 89.5, 102.3 and 95.9 gwas observed under the treatment N_1 (75% RDN) during 2019-20, 2020-21 and in pooled results, accordingly.Profound influence of nitrogen on crop growth seems to be due to congenial nutritional environment of plant systems on account of its greater availability from soil media, which might have resulted in greater synthesis of amino acids, proteins and growth promoting substances, which seems to have enhanced the meristematic activity and increased cell division and their elongation. Further, application might have increased interception, absorption and utilization of radiant energy which in turn increased photosynthesis and thereby crop growth. Similar results were reported by Agung*et al.* (2013), Sawargaonkar*et al.* (2013) and Olugbemi*et al.* (2017) in sweet sorghum; Pennaiah (2005), Hassan *et al.* (2010), Basava (2012), Khanna (2013), Brar*et al.* (2019), Lakshmi *et al.* (2020) and Vineela*et al.* (2021) in maize.

The interaction effect between drip irrigation schedules and nitrogen fertigation levels (I x N) for dry matter accumulation plant^{-1} at harvest was found significant during 2019-20, 2020-21 and in pooled results (Table 3, 4 and 5). Application of irrigation through drip at 0.8 PEF and fertilized the crop with 100% RDN through drip fertigation (I_2N_2) produced significantly maximum dry matter accumulation plant^{-1} at harvest of 127.7 g plant^{-1} during 2019-20 which was remained statistically at par with treatment combinationI_2N_3 during 2019-20. Application of irrigation at 0.6 PEF through drip and fertilized the crop with 75% RDN through fertigation (I_1N_1) recorded significantly minimum dry matter accumulation plant^{-1} at harvest of 74.9 g during 2019-20 and it was remained at par with treatment combination I_1N_2 and I_2N_1.During the year 2020-21, application of irrigation through drip at 0.8 PEF and fertilized the crop with 100% RDN through drip fertigation (I_2N_2) produced significantly maximum dry matter accumulation plant^{-1} at harvest of 146.5 g and which was remained statistically at par with treatment combination I_3N_2, I_2N_3 and I_3N_3. Significantly minimum dry matter accumulation plant^{-1} at harvest of 94.2 g plant^{-1} was recorded with the application of irrigation at 0.6 PEF through drip and fertilizing the crop with 75% RDN through drip fertigation (I_1N_1) and it was comparable with treatment combination I_1N_2, I_2N_1 and I_3N_1.Application of irrigation through drip at 0.8 PEF and fertilized the crop with 100% RDN through drip fertigation (I_2N_2) produced significantly maximum dry matter accumulation plant^{-1} at harvest of 137.1 g on pooled data basis and which was remained statistically at par with treatment combinationI_2N_3. Significantly lower dry matter accumulation plant^{-1} at harvest of 84.5 g was recorded with application of irrigation at 0.6 PEF through drip and application of 75% RDN through drip fertigation (I_1N_1) and it was remained on same bar with treatment combination I_1N_2 and I_2N_1.

3.2 Grain yield and dry fodder yield:

A perusal of data furnished in Table 6 revealed that different drip irrigation schedules significantly influenced grain yield during the year 2019-20, 2020-21 and in pooled results. Significantly higher grain yield of 1391, 1622 and 1506 kg ha^{-1} during 2019-20, 2020-21 and in pooled results, respectively was recorded when sweet sorghum was irrigated through drip at 1.0 PEF (I_3), however it remained statistically at par with I_2*i.e.* irrigating the crop through drip at 0.8 PEF during 2019-20, 2020-21 and in pooled results. Irrigating the crop through drip at 0.6 PEF produced significantly minimum grain yield of 1027, 1256 and 1142 kg ha^{-1} during 2019-20, 2020-21 and in pooled results, respectively. The per cent increase in grain yield under drip irrigation scheduled at 1.0 PEF (I_3) over (I_1) 0.6 PEF were to the tune of 35.4, 29.1 and 31.9% during 2019-20, 2020-21 and in pooled results, respectively.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 favoured 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 and number of grains $earhead^{-1}$ ultimately increasing higher grain yield. Similar findings were also reported by Hamidreza*et al.* (2011) and Salemi*et al.* (2011) in maize crop, Ibrahim *et al.* (2013), Sepaskhah and Ghasemi (2008) and Satish *et al.* (2016b) in sorghum crop. Lower grain yield was observed with deficit drip irrigation scheduled at 0.6 PEF; might be due to moisture stress leading to reduced test weight, grain weight, ear head weight and number of grains ear $head^{-1}$. The results confirms the findings of Maman*et al.* (2003) and Shirazi*et al.* (2011) in maize crop and Satish *et al.* (2016b) in sorghum.

The data presented in Table 10 revealed that dry fodder yield of sweet sorghum significantly affected due to different drip irrigation schedules during both the years and in pooled results. Irrigating the crop through drip irrigation at 1.0 PEF (I_3) recorded significantly higher dry fodder yield of 15378, 17893 and 16635 kg ha^{-1} during 2019-20, 2020-21 and in pooled results, respectively and it was found statistically at par with I_2 (Drip irrigation scheduled at 0.8 PEF) during 2019-20, 2020-21 and in pooled results. Significantly lower dry fodder yield of 11340, 13872 and 12606 kg ha^{-1} was recorded when crop was irrigated through drip at 0.6 PEF (I_1) during 2019-20, 2020-21 and in pooled results, respectively. The per cent increase in dry fodder yield of sweet sorghum with irrigating the sweet sorghum through drip at 1.0 PEF (I_3) were to the tune of 35.6, 29.0 and 32.0% over drip irrigation scheduled at 0.6 PRF (I_1) during 2019-20, 2020-21 and in pooled results, respectively.Which might be due to positive effect of irrigation on plant growth and sweet sorghum crop might have responded well to the applied higher irrigation through drip as sweet sorghum is highly responsive to nutrients and water. The fact that irrigation level increased the availability and maintaining higher soil moisture in the root zone throughout the crop period which reflected in higher relative leaf water content and subsequently in development of yield component and grain and fodder yields. As water tension increases, the available moisture content decreases and those roots have to exert more energy to get the water from the soil particles. The higher irrigation did not cause water stress at any stage providing favorable conditions for crop growth resulting in increased grain and fodder yields.This could be attributed under more favoured soil moisture availability, better vegetative growth; more dry matter production resulted in higher biological yield as compared to less frequency irrigation scheduling treatments. Similar responses were observed by Singh (2001), Bandyopadhayay and Mallick (2003),Sanjeev *et al.* (2006), Asimand Mohamed(2011), Bozkurt *et al.* (2011), Patil*et al.* (2011), Basava (2012), Brar*et al.* (2019) and Lakshmi *et al.* (2020) in maize; Patel *et al.* (2012) in fennel and Satish *et al.* (2016b) in sorghum.

An appraisal of data presented in Table 7 indicated that different nitrogen fertigation levels exhibited their significant influence on grain yield during the year 2019-20, 2020-21 and in pooled results. Significantly higher grain yield of 1337, 1603 and 1470 kg ha^{-1} during 2019-20, 2020-21 and in pooled results, respectively was recorded when crop was fertilized with 125% RDN through drip fertigation (N_3). However, it was found at par with 100% RDN (N_2) applied through drip fertigation during both the years as well as on pooled data basis. On the contrary, application of 75% RDN through drip fertigation (N_1) recorded significantly minimum grain yield of 1135, 1287 and 1211 kg ha^{-1} during 2019-20, 2020-21 and in pooled results, respectively. The per cent increase in grain yield with the application of 125% RDN through drip fertigation (N_3) over N_1 (75% RDN through drip fertigation) were to the tune of 17.8, 24.5 and 21.4% during 2019-20, 2020-21 and in pooled results, respectively.Results presented in Table 10 indicated that nitrogen fertigation levels significantly influenced dry fodder yield during the year 2019-20, 2020-21 and in pooled analysis. Fertigation level N_3 (*i.e.* 125% RDN through drip fertigation) recorded significantly higher dry fodder yield of 14761, 17666 and 16214 kg ha^{-1} during 2019-20, 2020-21 and in pooled results, respectively which was at par with N_2 (*i.e.* 100% RDN through drip fertigation) during both the years and in pooled results. Application of 75% RDN through drip fertigation (N_1) produced significantly minimumdry fodder yield of 12588, 14250 and 13419 kg ha^{-1} during 2019-20, 2020-21 and in pooled results, respectively. The per cent increase in dry fodder yield with the application of 125% RDN through drip over 75% RDN through drip fertigation were to the tune of 17.3, 24.0 and 20.8% during 2019-20, 2020-21 and in pooled results, respectively.Increase in yield under higher nitrogen fertigation schedules might be due to build-up of soil fertility that led to increased nutrient availability that accelerating the process of cell division, enlargement and elongation which in turn showed luxuriant vegetative growth and resulted in higher fodder yield. Similar results were reported by Sonar (2001), Hassanein*et al.* (2007), Sampathkumar and Pandian (2010), Muthukrishnan and Fanish (2011), Basava (2012), Fanish (2013), Ibrahim *et al.* (2016), Brar*et al.* (2019), Yadav *et al.* (2019) and Lakshmi *et al.* (2020).

Application of irrigation through drip at 0.8 PEF and fertilized the crop with 100% RDN through drip fertigation (I_2N_2) produced significantly maximum grain yield of 1631 kg ha^{-1} during 2019-20 which was remained statistically at par with treatment combinationI_2N_3 during 2019-20 (Table 7). Application of irrigation at 0.6 PEF through drip and fertilized the crop with 75% RDN through fertigation (I_1N_1) recorded significantly minimum grain yield of 960 kg ha^{-1} during 2019-20. During the year 2020-21, application of irrigation through drip at 0.8 PEF and fertilized the crop with 100% RDN through drip fertigation (I_2N_2) produced significantly maximum grain yield of 1815 kg ha^{-1} and which was remained statistically at par with treatment combination I_3N_2, I_3N_3 and I_2N_3 (Table 8). Significantly minimum grain yield of 1190 kg ha^{-1} was recorded with the application of irrigation at 0.6 PEF through drip and fertilizing the crop with 75% RDN through drip fertigation (I_1N_1).Application of irrigation through drip at 0.8 PEF and fertilized the crop with 100% RDN through drip fertigation (I_2N_2) produced significantly maximum grain yield of 1723 kg ha^{-1} on pooled data basis and which was remained statistically at par with treatment combinationI_2N_3(Table 9). Significantly lowergrain yield of 1075 kg ha^{-1} was recorded with application of irrigation at 0.6 PEF through drip and application of 75% RDN through drip fertigation (I_1N_1).

Significantly maximum dry fodder yield of 18032 kg ha^{-1} during 2019-20 (Table 11) was recorded with irrigating the crop through drip at 0.8 PEF and fertilizing with 100% RDN through drip fertigation (I_2N_2) and it was found on par with I_2N_3 (drip irrigation at 0.8 PEF with drip fertigation of 125% RDN). The treatment combination I_1N_2 recorded significantly lower dry fodder yield of 10666 kg ha^{-1}.Application of drip irrigation at 0.8 PEF and fertilizing the crop with 100% RDN through drip fertigation recorded significantly maximum dry fodder yield of 20058 kg ha^{-1} (Table 12) and it was found at par with treatment combination I_3N_2, I_3N_3 and I_2N_3 during 2020-21. Significantly lower dry fodder yield of 13194 kg $ha^{-1}$was producedunderthe treatment combination I_1N_1 (application of irrigation through drip at 0.6 PEF with fertigation of 75% RDN) being at par with I_1N_2, I_2N_1,I_1N_3 and I_3N_1.Significantly maximum dry fodder yield of 19045 kg ha^{-1} on pooled data basis was recorded with irrigating the crop through drip at 0.8 PEF and fertilizing the sweet sorghum with 100% RDN through drip fertigation (I_2N_2) and it was found on par with treatment combination I_2N_3 (*i.e.* Drip irrigation at 0.8 PEF with fertigation of 125% RDN) on pooled results basis (Table 13). Treatment combination I_1N_1 recorded significantly lower dry fodder yield of 11938 kg ha^{-1} but it was found on par with I_1N_2 and I_2N_1.

3.3 Water use efficiency and Nitrogen use efficiency:

Irrigating sweet sorghum crop through drip at 0.8 PEF (I_1) recorded significantly maximum water use efficiency of 4.23 and 4.52 kg ha^{-1} mm^{-1} during 2019-20 and in pooled results (Table 14), respectively and it was on par with drip irrigation scheduled at 0.6 PEF during 2019-20. The lower water use efficiency of 3.61 and 3.86 kg $ha^{-1}mm^{-1}$ was observed under drip irrigation scheduled at 1.0 PEF (I_3) during 2019-20 and in pooled results, respectively.Water use efficiency was higher under low irrigation regimes this might be due to water stress, applied water most effectively utilized by the crop. Increase in water use efficiency was mainly due to considerable saving of irrigation water, greater increase in yield of crops and higher nutrient use efficiency (Ramah, 2008).Similar results were reported by Karam*et al.* (2003), Fanish and Muthukrishnan (2011), Karimi and Gomrokchi (2011), Basava (2012), Hussein and Pibars (2012) and Patel *et al.* (2014).

Nitrogen use efficiency (Table 18) increased with increase in number of irrigations from I_1 (*i.e.*Drip irrigation scheduled at 0.6 PEF) to I_3 (*i.e.*Drip irrigation scheduled at 1.0 PEF). Treatments I_1, I_2 and I_3 which recorded NUE of 13.08, 16.95 and 17.28 kg kg^{-1}, respectively. Irrigating the crop at 1.0 PEF through drip (I_3) recorded higher NUE followed by I_2 (*i.e.*Drip irrigation scheduled at 0.8 PEF). Increase in NUE with more number of irrigations might be due to better availability of moisture and nutrients throughout the growth stages in drip system leading to better uptake of nutrients for production of higher grain and fodder yields. These results are more or less similar to those reported by Padmaja and Raddy (2018) in rice, Karangia*et al.* (2019) in wheat, Wang *et al.* (2020) in maize and Damor (2021) in wheat.

The data furnished in Table 14 showed that water use efficiency was significantly influenced due to various nitrogen drip fertigation levels. Application of 125% RDN through drip fertigation (N_3) to sweet sorghum recorded significantly maximum water use efficiency of 4.11, 4.80 and 4.46 kg ha^{-1} mm^{-1} during 2019-20, 2020-21 and in pooled results, and it was statistically at par with N_2 (100 % RDN through drip fertigation) during individual years and in pooled results. Significantly lower WUE of 3.46, 3.88 and 3.67 kg $ha^{-1}mm^{-1}$ was recorded with 75% RDN fertigation (N_1) during both the years and in pooled results, respectively.Water use efficiency (Table 14) was significantly influenced by different nitrogen fertigation levels. Maximum water use efficiency was noted in N_3 (*i.e.* 125% RDN through drip fertigation). Minimum water use efficiency was found in N_1 (*i.e.* 75% RDN through drip fertigation). This might be due to split application of fertilizer which frequently increases crop yields, thus, increasing crop water use efficiency. Adequate levels of essential plant nutrients are needed to optimize crop yields and WUE. The results are in line with that of Fanish (2013), Khanna (2013), Bibe (2016) and Patel *et al.* (2016) in maize and Sawargaonkar*et al.* (2013) in sweet sorghum.

The effect of different nitrogen fertigation levels on nitrogen use efficiency (Table 18) was found significant. Significantly higher nitrogen use efficiency was recorded when crop was fertilized with 75% RDN (N_1) through drip fertigation and lower nitrogen use efficiency was recorded when crop was fertilized with 125% RDN (N_3) through fertigation. The fertigation allows application of right quantity of nutrients uniformly to the wetted root volume, where the active roots are concentrated and this helps to enhance fertilizer use efficiency. This was due to better availability of moisture and nutrients throughout the growth stages in drip and fertigation system leads to better uptake of nutrients and production of sweet sorghum. Fertigation saves fertilizer nutrients as it permits application of fertilizer in small quantity at a time matching with the plants nutrient need thus, leading to higher fertilizer use efficiency. These results are similar to those reported by Hassanein*et al.* (2007), Ramah (2008) in maize and Yolcu and Cetin(2015) in silage corn.

The data furnished in Table 15 revealed that irrigating the crop at 0.8 PEF through drip and fertilizing with 100% RDN through drip fertigation (I_2N_2) recorded significantly maximum water use efficiency of 4.97 kg ha^{-1} mm^{-1} during 2019-20 and it was found at par with I_2N_3. Minimum water use efficiency of 3.23 kg ha^{-1} mm^{-1} was observed under treatment I_2N_1 (*i.e.* Irrigating the crop through drip at 0.8 PEF and application of 75% RDN through drip fertigation).Maximum water use efficiency of 5.40 kg ha^{-1} mm^{-1} was noted when crop was irrigated through drip at 0.8 PEF and fertilized the crop with 100% RDN through drip fertigation and it was found on par with I_2N_3 (*i.e.* Irrigating the crop through drip at 0.8 PEF and application of 125% RDN through drip fertigation) and I_1N_3(*i.e.* Irrigating the crop through drip at 0.6 PEF and application of 125% RDN through drip fertigation)during 2020-21 (Table 16). Minimum water use efficiency of 3.46 kg ha^{-1} mm^{-1} was noted when crop was irrigated at 1.0 PEF through drip irrigation and fertilizing the crop with 75% RDN through fertigation (I_3N_1) in 2020-21.The results furnished in Table 17 revealed that treatment combination I_2N_2 (*i.e.* Drip irrigation scheduled at 0.8 PEF and application of 100% RDN through drip fertigation) recorded maximum WUE of 5.19 kg $ha^{-1}mm^{-1}$ which remained at par with the treatment combination I_2N_3. Minimum WUE of 3.53 kg ha^{-1} mm^{-1} was observed under treatment combination I_3N_1 (*i.e.* Drip irrigation scheduled at 1.0 PEF and application of 75% RDN through drip fertigation) which was found at par with treatment combination I_2N_1 and I_1N_3 on pooled basis.

The data furnished in Table 19 revealed that irrigating the crop at 1.0 PEF through drip and fertilizing the crop with 75% RDN through drip fertigation (I_3N_1) recorded significantly maximum nitrogen use efficiency of 20.50 kg kg^{-1} during 2019-20. Minimum nitrogen use efficiency of 10.22 kg kg^{-1} was observed under treatment I_1N_3 (*i.e.* Irrigating the crop through drip at 0.6 PEF and application of 125% RDN through drip fertigation).Significantly maximum nitrogen use efficiency of 20.26 kg ha^{-1} during 2020-21 (Table 20) was noted with irrigating the crop through drip at 1.0 PEF and fertilizing with 75% RDN through drip fertigation (I_3N_1) and it was found on par with I_2N_1 (*i.e.* Drip irrigation at 0.8 PEF with drip fertigation of 75% RDN), I_2N_2 (*i.e.* Drip irrigation at 0.8 PEF with drip fertigation of 100% RDN) and I_3N_2 (*i.e.* Drip irrigation at 1.0 PEF with drip fertigation of 100% RDN). The treatment combination I_1N_3 recorded significantly lower nitrogen use efficiency of 12.07 kg ha^{-1}.Maximum nitrogen use efficiency of 20.38 kg kg^{-1} was noted when crop was irrigated through drip at 1.0 PEF and fertilized the crop with 75% RDN through drip fertigation (I_3N_1) and it was found on par with I_2N_2 (*i.e.* Irrigating the crop through drip at 0.8 PEF and application of 100% RDN through drip fertigation) on pooled data basis (Table 21). Minimum nitrogen use efficiency of 11.15 kg kg^{-1} was noted when crop was irrigated at 0.6 PEF through drip irrigation and fertilizing the crop with 125% RDN through fertigation (I_1N_3) on pooled data basis.

Table 1: Effect of drip irrigation schedules and nitrogen fertigation levels on plant height of sweet sorghum at harvest

Treatments		Plant height at harvest (cm)		
		2019-20	2020-21	Pooled
Drip irrigation schedules (I)				
I_1:	Drip irrigation 0.6 PEF	182.1	183.4	182.8
I_2 :	Drip irrigation 0.8 PEF	214.0	211.6	212.8
I_3 :	Drip irrigation 1.0 PEF	219.7	221.0	220.3
	S.Em. ±	6.9	6.5	4.7
	C.D. (P=0.05)	23.9	22.5	14.6
	C.V. (%)	11.67	10.99	11.34
Nitrogen fertigation (N)				
N_1:	75% RDN	178.0	178.6	178.3
N_2:	100% RDN	216.6	213.8	215.2
N_3:	125% RDN	221.1	223.6	222.4
	S.Em. ±	6.8	6.1	4.6
	C.D. (P=0.05)	20.1	18.3	13.1
	C.V. (%)	11.44	10.38	10.92
I x N interaction				
	S.Em. ±	11.7	10.6	7.9
	C.D. (P=0.05)	NS	NS	NS

Table 2: Effect of drip irrigation schedules and nitrogen fertigation levels on dry matter accumulation of sweet sorghum at harvest

Treatments		Dry matter accumulation at harvest (g plant^{-1})		
		2019-20	2020-21	Pooled
Drip irrigation schedules (I)				
I_1:	Drip irrigation 0.6 PEF	82.3	101.3	91.8
I_2 :	Drip irrigation 0.8 PEF	109.9	129.9	119.9
I_3 :	Drip irrigation 1.0 PEF	111.2	130.3	120.7
	S.Em. ±	2.4	3.5	2.1
	C.D. (P=0.05)	8.4	12.2	6.6
	C.V. (%)	8.30	10.12	9.45
Nitrogen fertigation (N)				
N_1:	75% RDN	89.5	102.3	95.9
N_2:	100% RDN	106.7	129.3	118.0
N_3:	125% RDN	107.1	129.9	118.5
	S.Em. ±	2.3	3.0	1.9
	C.D. (P=0.05)	6.9	9.0	5.5
	C.V. (%)	8.01	8.67	8.43
I x N interaction				
	S.Em. ±	4.1	5.2	3.3
	C.D. (P=0.05)	12.0	15.5	9.5

Table 3: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on dry matter accumulation (g plant^{-1}) of sweet sorghumat harvest during 2019-20.

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	74.9	83.3	110.5
N_2	81.4	127.7	111.2
N_3	90.8	118.6	111.8
		S.Em. ±	4.4
		C.D. (P=0.05)	12.0

Table 4: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on dry matter accumulation (g plant^{-1}) of sweet sorghumat harvest during 2020-21.

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	94.2	103.7	109.1
N_2	98.8	146.5	142.6
N_3	110.9	139.5	139.4
		S.Em. ±	5.2
		C.D. (P=0.05)	15.5

Table 5: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on dry matter accumulation (g plant^{-1}) of sweet sorghumat harvest on pooled basis.

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	84.5	93.5	109.8
N_2	90.1	137.1	126.9
N_3	100.9	129.0	125.6
		S.Em. ±	3.3
		C.D. (P=0.05)	9.5

Table 6: Effect of drip irrigation schedules and nitrogen fertigation levels on grain yield of sweet sorghum

Treatments		Grain yield (kg ha^{-1})		
		2019-20	2020-21	Pooled
Drip irrigation schedules (I)				
I_1:	Drip irrigation 0.6 PEF	1027	1256	1142
I_2 :	Drip irrigation 0.8 PEF	1388	1613	1501
I_3 :	Drip irrigation 1.0 PEF	1391	1622	1506
	S.Em. ±	40	56	35
	C.D. (P=0.05)	140	194	106
	C.V. (%)	11.04	12.95	12.23
Nitrogen fertigation (N)				
N_1:	75% RDN	1135	1287	1211
N_2:	100% RDN	1334	1601	1468
N_3:	125% RDN	1337	1603	1470
	S.Em. ±	33	42	27
	C.D. (P=0.05)	97	124	76
	C.V. (%)	8.92	9.68	9.40
I x N interaction				
	S.Em. ±	57	72	46
	C.D. (P=0.05)	168	215	132

Table 7: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on grain yield (kg ha^{-1}) of sweet sorghum during 2019-20

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	960	1061	1384
N_2	971	1631	1401
N_3	1149	1473	1388
		S.Em. ±	57
		C.D. (P=0.05)	168

Table 8: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on grain yield (kg ha^{-1}) of sweet sorghum during 2020-21

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	1190	1304	1368
N_2	1221	1815	1768
N_3	1358	1722	1729
		S.Em. ±	72
		C.D. (P=0.05)	215

Table 9: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on grain yield (kg ha^{-1}) of sweet sorghum on pooled basis

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	1075	1182	1376
N_2	1096	1723	1585
N_3	1254	1597	1558
		S.Em. ±	46
		C.D. (P=0.05)	132

Table 10: Effect of drip irrigation schedules and nitrogen fertigation levels on fodder yield of sweet sorghum

Treatments		Dry fodder yield (kg ha^{-1})		
		2019-20	**2020-21**	**Pooled**
Drip irrigation schedules (I)				
I_1:	Drip irrigation 0.6 PEF	11340	13872	12606
I_2 :	Drip irrigation 0.8 PEF	15360	17800	16580
I_3 :	Drip irrigation 1.0 PEF	15378	17893	16635
	S.Em. ±	407	613	368
	C.D. (P=0.05)	1407	2123	1134
	C.V. (%)	10.04	12.86	11.80
Nitrogen fertigation (N)				
N_1:	75% RDN	12588	14250	13419
N_2:	100% RDN	14730	17648	16189
N_3:	125% RDN	14761	17666	16214
	S.Em. ±	374	466	299
	C.D. (P=0.05)	1112	1385	857
	C.V. (%)	9.24	9.77	9.59
I x N interaction				
	S.Em. ±	648	807	518
	C.D. (P=0.05)	1925	2399	1485

Table 11: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on dry fodder yield (kg ha^{-1}) of sweet sorghum during 2019-20

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	10682	11780	15301
N_2	10666	18032	15491
N_3	12672	16268	15342
		S.Em. ±	648
		C.D. (P=0.05)	1925

Table 12: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on dry fodder yield (kg ha^{-1}) of sweet sorghum during 2020-21

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	13194	14430	15124
N_2	13396	20058	19491
N_3	15025	18911	19063
		S.Em. ±	807
		C.D. (P=0.05)	2399

Table 13: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on dry fodder yield (kg ha^{-1}) of sweet sorghum on pooled data basis

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	11938	13105	15213
N_2	12031	19045	17491
N_3	13849	17590	17202
		S.Em. ±	518
		C.D. (P=0.05)	1485

Table 14: Effect of drip irrigation schedules and nitrogen fertigation levels on water use efficiency of sweet sorghum

Treatments		Water use efficiency (kg ha^{-1}mm^{-1})		
		2019-20	**2020-21**	**Pooled**
Drip irrigation schedules (I)				
I_1:	Drip irrigation 0.6 PEF	3.79	4.54	4.16
I_2 :	Drip irrigation 0.8 PEF	4.23	4.80	4.52
I_3 :	Drip irrigation 1.0 PEF	3.61	4.11	3.86
	S.Em. ±	0.13	0.17	0.11
	C.D. (P=0.05)	0.44	NS	0.33
	C.V. (%)	11.45	13.10	12.45
Nitrogen fertigation (N)				
N_1:	75% RDN	3.46	3.88	3.67
N_2:	100% RDN	4.07	4.76	4.41
N_3:	125% RDN	4.11	4.80	4.46
	S.Em. ±	0.11	0.12	0.08
	C.D. (P=0.05)	0.32	0.36	0.23
	C.V. (%)	9.72	9.31	9.52
I x N interaction				
	S.Em. ±	0.19	0.21	0.14

C.D. (P=0.05)	0.56	0.62	0.40

Table 15: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on water use efficiency (kg ha^{-1} mm^{-1}) of sweet sorghum during 2019-20

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	3.54	3.23	3.59
N_2	3.58	4.97	3.64
N_3	4.24	4.49	3.60
		S.Em. ±	0.19
		C.D. (P=0.05)	0.56

Table 16: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on water use efficiency (kg ha^{-1} mm^{-1}) of sweet sorghum during 2020-21

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	4.30	3.88	3.46
N_2	4.41	5.40	4.48
N_3	4.90	5.12	4.38
		S.Em. ±	0.21
		C.D. (P=0.05)	0.62

Table 17: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on water use efficiency (kg ha^{-1} mm^{-1}) of sweet sorghum on pooled data basis

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	3.92	3.56	3.53
N_2	4.00	5.19	4.06
N_3	4.57	4.81	3.99
		S.Em. ±	0.14
		C.D. (P=0.05)	0.40

Table 18: Effect of drip irrigation schedules and nitrogen fertigation levels on nitrogen use efficiency of sweet sorghum crop

Treatments		Nitrogen use efficiency (kg kg^{-1})		
		2019-20	2020-21	Pooled
Drip irrigation schedules (I)				
I_1:	Drip irrigation 0.6 PEF	11.74	14.42	13.08
I_2 :	Drip irrigation 0.8 PEF	15.64	18.26	16.95
I_3 :	Drip irrigation 1.0 PEF	16.13	18.42	17.28
	S.Em. ±	0.44	0.57	0.36
	C.D. (P=0.05)	1.52	1.97	1.11
	C.V. (%)	10.52	11.55	11.17
Nitrogen fertigation (N)				
N_1:	75% RDN	16.81	19.07	17.94
N_2:	100% RDN	14.83	17.79	16.31
N_3:	125% RDN	11.88	14.25	13.06
	S.Em. ±	0.37	0.41	0.28
	C.D. (P=0.05)	1.10	1.22	0.79
	C.V. (%)	8.84	8.37	8.60
I x N interaction				
	S.Em. ±	0.64	0.71	0.48
	C.D. (P=0.05)	1.91	2.12	1.38

Table 19: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on nitrogen use efficiency (kg kg^{-1}) of sweet sorghum during 2019-20

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	14.22	15.72	20.50
N_2	10.79	18.12	15.57
N_3	10.22	13.09	12.33
		S.Em. ±	0.64
		C.D. (P=0.05)	1.91

Table 20: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on nitrogen use efficiency (kg kg^{-1}) of sweet sorghum during 2020-21

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	17.64	19.32	20.26
N_2	13.56	20.16	19.65
N_3	12.07	15.31	15.37
		S.Em. ±	0.71
		C.D. (P=0.05)	2.12

Table 21: Interaction effect between drip irrigation schedules and nitrogen fertigation levels on nitrogen use efficiency (kg kg^{-1}) of sweet sorghum on pooled data basis

Drip irrigation schedules / Fertigation	I_1	I_2	I_3
N_1	15.93	17.52	20.38
N_2	12.18	19.14	17.61
N_3	11.15	14.20	13.85
		S.Em. ±	0.48
		C.D. (P=0.05)	1.38

4. Conclusion:

Based on the results of two years experimentation, it can be concluded that for getting higher grain and fodder yields, sweet sorghum should be applied two common surface irrigation (first immediately after sowing and second 7 days after first irrigation) each of 50 mm depth followed by scheduling drip irrigation at 0.8 PEF (operating pressure: 1.2 kg cm-2 and lateral spacing: 120 cm) at alternate day and crop should be fertilized with 100% RDN through drip fertigation out of which, 50% RDN as basal and remaining 50% RDN in five equal splits at 10 days interval through fertigation started from 35 DAS.

Missing:

Recommendations

Declaration of conflict of interest

5. References:

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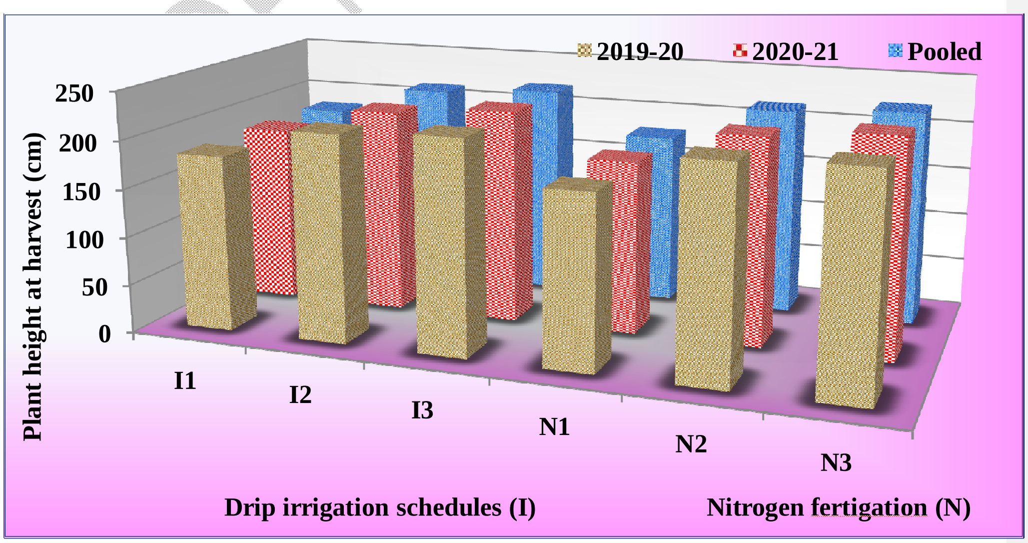

Fig. 1: Plant height (at harvest) of sweet sorghum as influenced by drip irrigation schedules and nitrogen fertigation levels

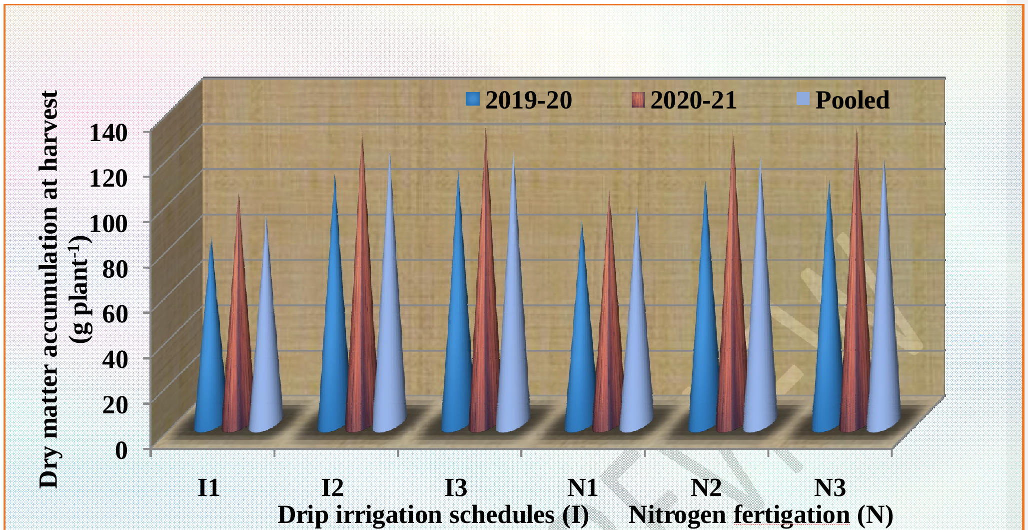

Fig. 2: Dry matter accumulation (at harvest) of sweet sorghum as influenced by drip irrigation schedules and nitrogen fertigation levels

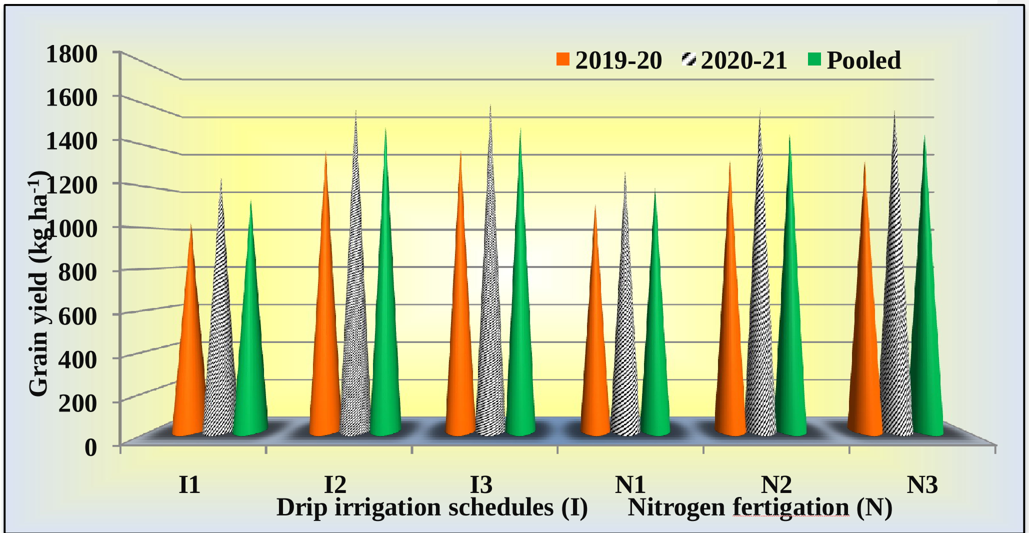

Fig. 3: Grain yield of sweet sorghum as influenced by drip irrigation schedules and nitrogen fertigation levels

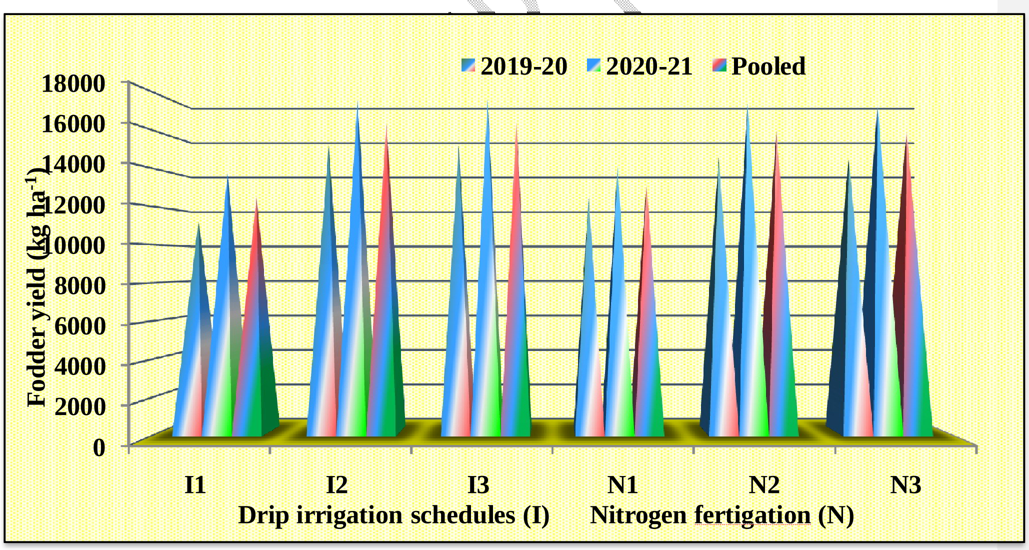

Fig. 4: Dry fodder yieldof sweet sorghum as influenced by drip irrigation schedules and nitrogen fertigation levels

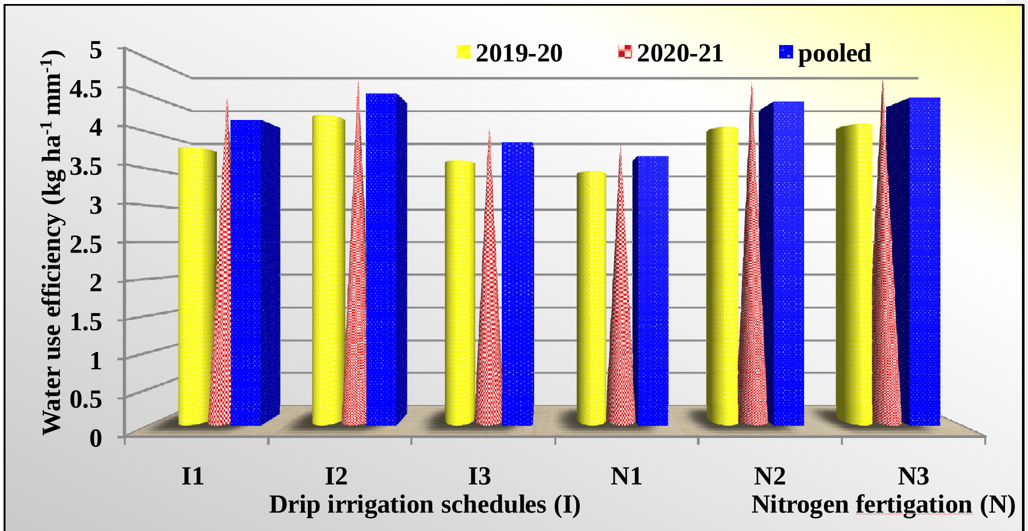

Fig. 5: Water use efficiencyof sweet sorghum as influenced by drip irrigation schedules and nitrogen fertigation levels

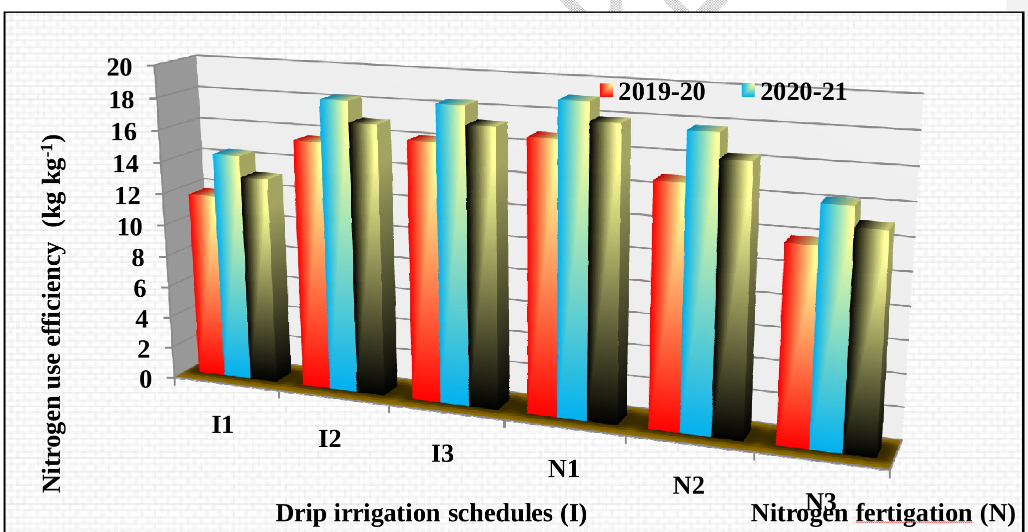

Fig. 6: Nitrogen use efficiency of sweet sorghum as influenced by drip irrigation schedules and nitrogen fertigation levels