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Research Article

IMPACTS OF DATE OF SOWING AND CULTIVARS ON GROWTH AND DEVELOPMENT OF FODDER SORGHUM – A REVIEW

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A B S T R A C T

Livestock rearing is one of the major occupations in India and is making significant contribution to the country GDP. The regional and seasonal variations in the temperature and rainfall distribution have been the major factors influencing the economy of a region. In India, 70% of total fodder grown region is rainfed and vulnerable to climatic variability. Sorghum crop is adaptive to vast environmental conditions in India. It is able to sustain high temperature and less moisture conditions. It provides green fodder to the animals for a considerable length of period. Now-a-days many new improved cultivars of fodder sorghum are coming up for increased production and quality of fodder. Therefore, it is necessary to study the response of these cultivars to different times of sowings. The sowing time of the sorghum affects the fodder supply to the considerable extent and hence, optimum time of sowing should be done in order to achieve maximum fodder yield along with maintaining the regular supply of the green fodder including quality. Three climatic parameters *viz.*, temperature, rainfall and light are most important for optimum crop growth and development and thereby exploits the potentiality of a crop.

Study on performance of fodder sorghum varieties under varied times of sowing is in its Infancy. Literature on earlier work pertaining to fodder sorghum were collected under some broad headings like effect of weather elements on growth and development and growth, quality parameters and yield of fodder sorghum as influenced by time of sowing and varieties are briefly reviewed in this treatise.

INTRODUCTION

The minimum temperature for germination of sorghum is 7˚C to 10˚C, while optimum is 18˚C to 21˚C. Recommended sowing time is when the soil temperature at sowing depth at sunrise reaches 20˚C (Stoffer and Ripper 1963). Maunder (1972) reported that sorghum requires warm weather for development and it cannot grow properly or set seed at temperatures below 18˚C - 21˚C. It cannot recover from freezing temperature except in the juvenile stage. A study carried out at Gujart, India revealed that maximum temperature of 30 to 35˚C is required during vegetative and maturity periods of sorghum (Pandey and Gupta 1990). Alagaraswamy and Ritchie (1991) reported that optimum temperature for vegetative development of sorghum was 34^{o}C with base temperature of 8^{o}C. Sorghum requires warmer soil temperatures compared with many other crops such as soybean and maize and it requires soil temperature of 20°C. An optimum temperature of 31^{o}C is needed for preanthesis reproductive development of sorghum (Prasad *et al.,* 2006). The work of miller *et al*. Shows that while long nights hasten the flowering in tropical varieties, nights as short as 11 hours do not delay the flowering of temperate zone varieties. Minimum temperature for growth is 15˚C, while the optimum range is 27˚C - 30˚C. Temperature above 38˚C is harmful. Maximum dry matter production and grain yield were observed at optimum temperatures of 27 and 22˚C respectively, compared to temperatures lower or higher by 3 to 6˚C to optimum temperatures (Downs, 1972). Studies of Ahmed *et al.* (2007) inferred that temperature had shown significant positive correlation with LAI and plant height of sorghum. Evapotranspiration rate increased with canopy development upto panicle primordial initiation and declined sharply thereafter, indicating that the peak period of water use in M.P. chari coincides with transitional zone of vegetative and reproductive phases fodder sorghum. The total evapotranspirational losses were 286.2 mm in dry year and 407.1 mm in normal year with mean ET rate of 5.6 and 6.1 mm/day, respectively (Lal and Shukla, 1985). The average ET was found to be 346.7 mm with daily value of 5.8 mm. Thus weather conditions and soil moisture status determine to a great extent the ET rate. In another study reported by Behari and Hazara, it was observed that on average basis the highest ET rate was at boot stage (5.93) followed by the flowering (5.53), vegetative (5.07) and establishment phase (3.90). This

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indicated that the water requirement of crop during boot stage is quite critical followed by the vegetative phase. The WUE varied between 20.03 to 39.54 kg·DM/ ha-mm.

Effect of Relative Humidity

Relative humidity was found to be significantly and positively correlated with sorghum yield during the flowering stage with increasing photosynthetic rate (Ibrahim *et al.,* 2011). Hugar and Halikatti (2015) from their studies reported positive association of maize yield with relative humidity during sixth leaf to tasseling, tasseling to silk, silk to milk and milk to physiological maturity and negative correlation during sowing to seedling emergence and seedling emergence to sixth leaf.

Effect of Solar Radiation

The highest crop growth rate reported for sorghum was 43.6 g m^{-2} day^{-1} with the average shortwave radiation of 26.5 MJ m^{-2} day^{-1} for the whole period (Fischer and Wilson 1975). Total dry matter production of a cereal crop is known to be proportional to the total amount of intercepted radiation, which itself is largely determined by the size of leaf area and its distribution with time (Biscoe and Gallagher, 1978). Ahmed *et al.* (2007) found that solar radiation had shown negative correlation with plant height and LAI. Accumulated solar radiation along the sorghum cycle below 1900 MJ m^{-2} reduced the yield. The changes in solar radiation during crop period lead to the largest yield variation. A 20 per cent increment in the solar radiation resulted in a 30 per cent increase in yield. This effect is however no linear in the sense that 10 per cent reduction of radiation is associated with a 35 per cent drop in yield (Grossi *et al.,* 2015).

Effect of Rainfall

Boomiraj *et al*. (2012) reported that increased yields of rainfed sorghum in Semi Arid Tropics (SAT) are due to reduction in maximum temperature and increase in rainfall. Sorghum is less sensitive to low rainfall and rainfall before sowing is very much helpful to maintain optimum plant population and for setting increased sorghum yields. After emergence the average rainfall of more than 80 mm seems to be sufficient for the crop (Pandey and Gupta 1990). Tack *et al.* (2017) from their experiment reported that the sorghum was exhibiting sensitivity to high precipitation and tolerance to low precipitation.

Growth, Quality Parameters and Yield of Fodder Sorghum As Influenced by Time of Sowing

Growth Parameters

Plant Height

Salunke *et al.* (2003) observed that maximum plant height of sorghum was recorded in 29th October sowing than 29th September and 29th November sowings. Chitte *et al*. (2008) conducted an experiment on sorghum crop at Rahuri, Maharastra with various dates of sowing in early *summer* and reported that plant height of the crop at all stages was significantly superior with adopted sowing date of 16th December compared to later adopted sowing dates of 3rd January and 17th January. Chandrika *et al*. (2012) conducted an experiment on sandy loam soils of Hyderabad, Telangana State and revealed that fodder bajra sown during I FN of February recorded taller plants than other dates of sowing with II FN of January, II FN of February and I FN of March. Girase *et al*. (2016) from their studies on summer pearl millet observed that sowing of summer pearl millet upto 5th MW (29th January to 4th February) produced significantly taller plants and delayed sowing after 5th MW resulted in decreased plant height.

Leaf Area

Salunke *et al.* (2003) observed that Leaf area index at physiological maturity of sorghum was significantly higher in 29th November sown crop than the early sown crop *i.e.* 29th September and 29th October. On other hand Raouf *et al.* (2013) observed a positive linear regression relationship of grain yield with leaf area (r = 0.50), leaf area index of sorghum (r = 53) under varied sowing dates. Among various dates of sowing in sweet sorghum higher Leaf area index was recorded with crop sown on 2nd week of October on clayey soils of Navasari (Desai *et al.,* 2015). An experiment conducted with improved sorghum cultivars on clay loam soils of Bihar revealed that 3rd March sown crop recorded significantly higher leaf area compared to 16th February sown crop Mishra *et al*. (2017).
Drymatter Production

Chitte *et al.* (2008) conducted an experiment on sorghum reported that plant height of sorghum at all the stages of crop growth and dry matter accumulation $plant^{-1}$ at 60 and 90 DAS were significantly superior in 16th December sowing than 3rd January. In a study conducted at Egypt found that dry matter yield significantly differed among five different sowing dates (7th April, 27th April, 17th May, 6th June and 26th June) and first and late of June sowing recorded significantly higher dry matter yield **(** Raouf *et al.,* 2013). In an experiment conducted at Parbhani, Maharastra with 4 dates of sowing *viz.,* 24th MW(11th June to 17th June), 25thMW(18th June to 24th June), 26th (MW 25th June to 1st July) and 27th MW (2nd July to 8th July) revealed that significantly superior and highest dry matter was observed in first sowing (24th MW) at all growth stages than other dates of sowing and it was at par with second sowing (25th MW) at 60 DAS (Karhale *et al.,* 2014).

Stem Diameter

Mishra *et al*. (2017) conducted an experiment with improved sorghum cultivars on clay loam soils of Bihar and reported that 3 March sown crop recorded significantly higher stem girth compared to 16th February sown crop. Among four different dates of sowings in sweet sorghum, crop sown on 2nd week of October recorded significantly higher stem diameter (Desai *et al.,* 2015).

Quality Parameters

Lattief *et al.* (2011) from their studies reported that crude protein content of forage pearl millet was not influenced by the adopted sowing date during summer. Chandrika *et al.* (2012) conducted an experiment with multicut fodder bajra genotypes on sandy loam of Hyderabad, Telangana State revealed that high crude protein yield was noticed with 1st FN of February over other dates of sowing, whereas, 1st FN of March was on par with 2nd FN of January. Fodder Maize crop sown later during 3rd week of November recorded higher crude protein content compared to the crop sown earlier during 1st week of October, 3rd week of October and 1st week of November similarly 3rd week of November recorded higher crude fibre content (Patel *et al.,* 2017). A study conducted at National Dairy Research Institute, Karnal, Haryana and revealed higher

ash content when fodder oats was sown during 11th October than other dates of sowing Amitkumar *et al.* (2012).

Fodder Yield

Chitte *et al*. (2008) conducted experiment on sorghum by adopting various dates of sowing at Rahuri, Maharashtra and reported that the crop sown early on 16th December recorded highest sorghum fodder yield compared to the crop sown at later dates on 3rdJanuary and 17th January. Deshmukh *et al*. (2009) reported that fodder yield in pearl millet was significantly higher in crop sown during 5th MW (29th January to 4th February) compared to 7th MW (12th February to 18th February) but on par with 3rd (29th January to 4th February) and 4th (29th January to 4th February) meteorological weeks on clay soils of Aurangabad, Maharastra. Desai *et al.* (2015) conducted an experiment on clay soils of Navasari, Gujarat and reported that sweet sorghum sown on 2nd week of October recorded higher dry fodder yield compared to the crop sown on 4th week of October, 2nd week of November and 4th week of November sown crop. An experiment conducted by Girase *et al*. (2016) at Maharastra revealed that among various dates of sowing of summer pearl millet, crop sown on 1st MW (1st January to 7th January) produced significantly higher fodder yield over late sowing in 9th MW (26th February to 4th March). Singh *et al.* (2017) conducted an experiment on loamy sand soils of Ludhiana, Punjab for two consecutive years on performance of maize under different dates of planting and revealed that crop planted on 20th February recorded highest dry stover weight than the 10th February and 2nd March planted crop.

Growth, Quality Parameters and Yield of Fodder Sorghum as Influenced by Varieties

Growth Parameters

Plant Height

Singh and Sumeriya (2005) in a study conducted on clay loam soils of Udaipur for two consecutive years on the performance of fodder sorghum cultivars UPFS-37, UPFS-38, SRF-239, SU-658 and HC-308 reported that UPFS-37 variety produced significantly taller plants compared to other varieties. Trivedi et al. (2010) revealed that among the four fodder sorghum varieties (Prathap Chari 1080, SPV 1179, SPV 1753 and CSV 23) tested, Prathap Chari 1080 produced significantly taller plants while CSV 23 produced the shortest plants during summer season on clay loam soils of Udaipur, Rajasthan

Rana *et al.* (2013) conducted experiment on fodder sorghum during *kharif* season on clay loam soils of Hisar and inferred that among fodder sorghum genotypes SPV 1846, SPV 1847, PC 1003, CSV 21F and HC 308, the maximum plant height was attained by genotype CSV 21F, which was significantly superior over SPV 1846 and SPV 1847. Mishra *et al*. (2015) reported that the sweet sorghum genotype SPV 1616 produced significantly taller plants followed by CSV15 at Directorate of Sorghum Research (DSR), Hyderabad during rainy season. Satpal *et al*. (2015) conducted an experiment with five fodder sorghum genotypes at Hisar during *kharif* season on sandy loam soils and observed that genotype CSV 30 F produced significantly taller plants compared to SPV 2185, SPV 2191, HC 308 and CSV 21F.

Leaf Area

Satpal *et al*. (2015) reported that the maximum leaf area index was recorded with the sorghum genotype SPV 2191 which was significantly superior over other genotypes SPV 2185, CSV 30 F, HC 308 and CSV 21F during *kharif* on sandy loam soils of Hisar. Mishra *et al.* (2017) conducted an experiment on sandy loam soils of Hyderabad and concluded that the leaf area was markedly influenced by sweet sorghum cultivars. They observed that significantly higher values of leaf area were associated with CSH 22SS followed by SSV 84 and SSV 74 and the lowest values were registered with HC 308. Srivastava *et al.* (2017) from their studies during *kharif* season on alfisols of Hyderabad reported that the fodder sorghum variety SPV 462 recorded significantly higher leaf area index compared to CSH 14 hybrid.

Dry Matter Production

Dixit *et al.* (2005) revealed that sorghum genotype SPH 960 proved significantly superior in producing higher number of green leaves per plant, leaf area index and dry matter accumulation over rest of the genotypes CSV 15, CSH 9 and SPV 1022. Among the forage sorghum varieties (UPFS-37, UPFS-38, SRF-239, SU-658 and HC-308) tested in two consecutive years at Udaipur under rainfed conditions on clay loam soils, the HC-308 variety recorded significantly higher dry fodder yield compared to other varieties (Singh and Sumeriya, 2005). Senthilkumar *et al.* (2009) evaluated Co 27 (single cut) and CoFS 29 (multicut) fodder sorghum varieties at Kattupakkam, Tamil Nadu and found that dry matter production of fodder from CoFS 29 was higher than Co 27 at 65 days after sowing. Buldak *et al.* (2010) from their experiment conducted on clay loam soils at Udaipur revealed that fodder sorghum variety, SSG 59-3 produced significantly higher dry matter per plant in first and second cuts over other genotypes (UTMC 534, CSH 20 MF, UTMCH 1304 and GK 909) tried.

Stem Diameter

A field experiment conducted at Targhadi, Gujarath revealed that significantly higher stem girth was recorded with CSH 5 compared to GFS 4 and Local gundari variety on medium black clay soils during *kharif* season (Akbari *et al.,* 2000). In an agronomic trail conducted at Hyderabad with different sorghum cultivars found that, the stem girth was significantly higher with SSV 74 but was on a par with SSV 84, CSH 22SS RSSV 104 and RSSV 167 on sandy loam soils (Mishra *et al.* 2017).

Quality Parameters

Crude Protein

Maximum crude protein content of fodder sorghum was recorded with Pratap Chari 1080 and SPV 1779 compared to the rest of the sorghum varieties tested on clay loam soils of Udaipur, Rajasthan (Trivedi *et al.*, 2010). A field experiment conducted by Bhoya *et al*. (2013) during summer revealed that fodder sorghum variety GFS 5 recorded significantly higher levels of crude protein. Rana *et al.* (2013) conducted an experiment at Hisar, Haryana to study the performance of fodder sorghum varieties SPV 1846, SPV 1847, PC 1003, CSV 21F and HC 308 and found that SPV 1846 recorded significantly higher crude protein content compared to the other varieties. Among various genotypes of fodder sorghum the higher crude protein was observed in HC 308 which was

on par with CSV 21F and SPV 2185, but significantly superior over SPV 2191 and CSV 30F (Satpal *et al*., 2015).

Crude Fibre

The experiment conducted on clay soils of Rajkot, Gujarat during *kharif* season revealed that crude fibre content of CSV 21 F fodder sorghum variety was significantly higher with seed rate of 60 kg ha^{-1} (Talpada *et al.* 2010). Bhoya *et al*. (2013) found that significantly higher crude fibre content was recorded with the fodder sorghum variety GFS 5 than GFS 4 during summer on loamy sand soil of Sardarkrushinagar, Gujarat. Satpal *et al*. (2015) conducted an experiment with five fodder sorghum genotypes SPV 2185, SPV 2191, HC 308, CSV 21F and CSV 30F during *kharif* at Hisar, Haryana on sandy loam soils. The results revealed highest dry fodder yield with CSV 30 F, which was on par with HC 308 and SPV 2191, but significantly superior over SPV 2185 and CSV 21F. A field experiment conducted at Kota, Rajasthan to evaluate the quality of fodder sorghum revealed that significantly higher crude fibre content was recorded with variety sugargraze over rest of the varieties (Meena *et al.,* 2017).

Ash Content

Ayub *et al*. (2010) reported maximum ash content was recorded in Hengari variety of fodder sorghum among the different varieties tested at Agronomic Research Unit of Faisalabad, Pakistan. In an experiment conducted at Kattupakkam, Tamil Nadu to evaluate Co 27 (single cut) and CoFS 29 (multicut) fodder sorghum varieties for proximate constituents analysis, the total ash content was significantly higher with CoFS 29 in all the five harvests than the Co 27 fodder sorghum (Senthilkumar *et al.,* 2009). Meena *et al.* (2017) conducted a field experiment at Kota, Rajasthan to evaluate the quality of fodder sorghum and concluded that significantly higher ash content was found in fodder sorghum variety sugargraze over local variety.

Fodder Yield

The results of the experiment conducted by Agrawal *et al.* (2005) revealed that significantly higher green fodder yield of fodder sorghum was obtained with variety J-195 compared to SPV-462 and J-6 on clay loam soils of Jabalpur, Madhya Pradesh. A field experiment carried out at Udaipur, Rajasthan on clay loam soils during *kharif* season revealed that forage sorghum variety HC-308 recorded significantly higher green fodder yield over UPFS-37, UPFS-38, SRF-239 and SU-658 (Singh and Sumeriya, 2005). The highest green fodder yield of CSV 21 F fodder sorghum variety obtained with seed rate of 60 kg ha^{-1} and fertilizer dose of 100 kg N and 50 kg P_2O_5 ha^{-1} during *kharif* on clay soils of Rajkot, Gujarat (Talpada *et al.,* 2010). A field experiment conducted on loamy sand soil Dantiwada Agricultural University, Gujarat during summer revealed that, among the varieties of fodder sorghum, GFS 5 performed better in respect of green forage than variety GFS 4 (Bhoya *et al*., 2013). The highest green fodder yield was recorded in genotype CSV 21F among different fodder sorghum genotypes studied during *kharif* season on clay loam soils of Hisar, Haryana (Rana *et al.,*2013). Satpal *et al*. (2015) conducted an experiment with five fodder sorghum genotypes (SPV 2185, SPV 2191, HC 308, CSV 21F and CSV 30F) at Hisar, Haryana during *kharif* season on sandy loam soils and they found that the highest green fodder yield was recorded with SPV 2191,which was on par with HC 308, SPV 2185, CSV 30F and significantly superior over CSV 21F.Among fodder sorghum varieties CSV 30F, CSV 21F, HC 308 and Local Check the highest fodder yield was obtained with CSV 30 F in multi locational trails (shinde *et.al.,* 2015).

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