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RESEARCH ARTICLE

Influence of sowing dates and nitrogen levels on the performance of summer-irrigated sorghum in the western agroclimatic zone of Tamil Nadu

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Abstract

Sorghum is an important Nutri-cereal and stable food crop for majority of the populations in the semi-arid tropical regions. Climate change is predicted to have a detrimental impact on growth and the productivity of sorghum. Optimising the sowing windows and nitrogen levels are the major agronomic management practices which determine the better productivity of the crop. The field experiment was conducted in split plot design with three levels of replications. The main plots consist of five dates of sowing *viz*., D_1-First fortnight of April, D_2-Second fortnight of April, D_3-First fortnight of May, D_4-Second fortnight of May and D_5-First fortnight of June. The sub plots include three different levels of nitrogen *viz*., N_1-75 % RDN, N_2-100 % RDN and N_3-125 % RDN. The sorghum crop variety K 12 was used in this experiment and it was raised fully under summer irrigated conditions during 2023. The results indicated that sorghum sown on second fortnight of May (D_4) recorded significantly higher the grain yield (4230.3 kg ha^{-1}) and the yield increases were 15.9 % compared to first fortnight of April (D_1-3649.5 kg ha^{-1}). Regarding varied nitrogen levels125 % RDN (N_3) registered highest grain yield (4063.6 kg ha^{-1}) which increase of 5.8 % compared to the 100 % RDN (N_2) (3839.5 kg ha^{-1}). Further the delayed sowing of sorghum combined with increased nitrogen level give the highest gross return (Rs. 134424 ha^{-1}), net return (Rs. 90100 ha^{-1}) and B:C ratio (3.03) under summer irrigated condition.

Keywords: economics; nitrogen levels; sorghum; sowing windows; summer irrigated

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] plays an important role in the food security of dryland areas as “Miracle Nutri-Cereals” providing nutritional and health security to all (1). Nowadays sorghum is gaining importance and said as “healthy food” due to its high dietary fibre ranges from 7.6 to 9.2 %, 72.6 % carbo-hydrates, 10 to 12 % proteins, 1.6 % mineral, 1.9 % fat and rich in amino acids like lysine, thiamine, riboflavin and folic acid. It is a stable food crop for millions of semi-arid residents, also known as the “King of Millets” (2). The sorghum crop is characterized by its tolerance of environmental conditions that are not suitable to produce other summer crops especially heat, drought and soil salinity, hence, it is called “Camel Crop” (3). Globally, sorghum is the fifth most important crop after rice, wheat, maize and barley, whereas in India it is the fourth largest crop. About 19.5 % of the world’s population and 27 % of India’s population takes sorghum as their primary food (4). Worldwide, sorghum is cultivated on about 41 million hectares to produce 64.20 million tonnes, with a productivity level of 1.60 tonnes per hectare whereas in India, the sorghum landscape is diverse. Among the states, Maharashtra leads in sorghum production, contributing 1.76 million tonnes, followed by Karnataka with 0.88 million tonnes, Rajasthan with 0.59 million tonnes and Tamil Nadu with 0.45 million tonnes (5). Compared with the global average, sorghum productivity in India is rather low, mostly because the crop is cultivated under rainfed conditions and has undergone unfavourable climatic conditions and stress during the growth stages (6).

Climate change is predicted to have a detrimental impact on growth and productivity of sorghum in tropical regions. According to IPCC sixth assessment report, the average global surface temperature had increased by 1.1 °C and these changes have a significant influence on productivity of grain crops, including sorghum (7). Selecting the optimal sowing time is a critical agronomic strategy that significantly influences a crop's vegetative growth, reproductive development, physiological maturity and overall the yield potential. The impact of sowing dates on sorghum production varies based on the specific environmental conditions prevailing during the crop's growing season (8). Considering the ever-changing daily weather variables, the time of sowing has a substantial impact on both crop growth and yield. Understanding this it is very much important to select the optimum sowing time which provide ideal growing conditions to obtain the higher yield of sorghum under summer irrigated conditions is highly needed.

Nitrogen is a crucial essential nutrient and often the most limiting factor in modern crop production. It plays a vital role in the synthesis of amino acids, proteins and pigments, such as chlorophyll (9). The time and the quantity of nitrogen application have the significant impact on the sorghum growth and productivity (10). Therefore, adoption of good nitrogen management strategies often results in large economic benefits to farmers. But there is little information available on sorghum growth and yield on variable rate of nitrogen application during summer irrigated conditions. Water is a major limiting factor for crop yield, especially in summer crops like sorghum. Although sorghum is one of the most drought-tolerant cereal crops and exhibits high Water Use Efficiency (WUE), inadequate water supply during critical growth stages such as germination, flowering and grain filling can significantly reduce productivity (11). Prolonged water stress can impair physiological processes, decrease biomass accumulation and ultimately lower grain yield (12). Considering the above fact the present investigation was undertaken to identify suitable sowing windows and nitrogen levels on better growth and yield of sorghum under summer irrigated conditions.

Materials and Methods

Study area

This study was designed and conducted in the Department of Agronomy at Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu, India. The field is geographically located at latitude 11.007631° N & longitude 76.9392637° E with an altitude of 426.7m above mean sea level. The study region is the western agro climate zone of Tamil Nadu, which comes under the semiarid region.

Experimental details

The field experiment was laid out in a split plot design with three replications. The main plot consists of five dates of sowing *viz.*, D_1-First fortnight of April, D_2-Second fortnight of April, D_3-First fortnight of May, D_4-Second fortnight of May and D_5-First fortnight of June. The subplots comprised three levels of nitrogen: N_1-75 % RDN (67.5 kg N ha^{-1}) (reduced level of nitrogen), N_2-100 % RDN (90 kg N ha^{-1}) (recommended dose of nitrogen) and N_3-125 % RDN (112.5 kg N ha^{-1}) (increased level of nitrogen).

Agronomic practices

The test crop is sorghum [*Sorghum bicolor* (L.) Moench] and the variety used for this experiment is K 12 (Kovilpatti 12), released by Tamil Nadu Agricultural University (TNAU), Coimbatore. The crop was fully raised under summer irrigated conditions in 2023 and spacing adopted for this experiment is 45×15 cm. The recommended dose of fertilizer for irrigated sorghum (90:45:45 kg NPK ha^{-1}) was applied in the form of urea, single super phosphate and muriate of potash. 50 % of the Recommended Dose of Nitrogen (RDN), the entire dose of phosphorous and potash were applied basally at the time of sowing. The two split applications applied the remaining 50 % of the nitrogen on 15^{th} day (25 %) and 30^{th} day (25 %) after the sowing of sorghum. Three levels of nitrogen were applied as per the subplot treatments schedule [N_1-75 % RDN (67.5 kg N ha^{-1}); N_2-100 % RDN (90 kg N ha^{-1}); N_3-125 % RDN (112.5 kg N ha^{-1})]. As given in the TNAU crop production guide 2020, all the agronomic practices were followed to cultivate the crop successfully.

Data and methods

The daily weather data on maximum temperature, minimum temperature and the amount of rainfall during the crop season were obtained from the Agro Climatic Research Centre, TNAU, Coimbatore. The daily data were converted into standard meteorological data during the crop growth period. The weather prevailed during crop

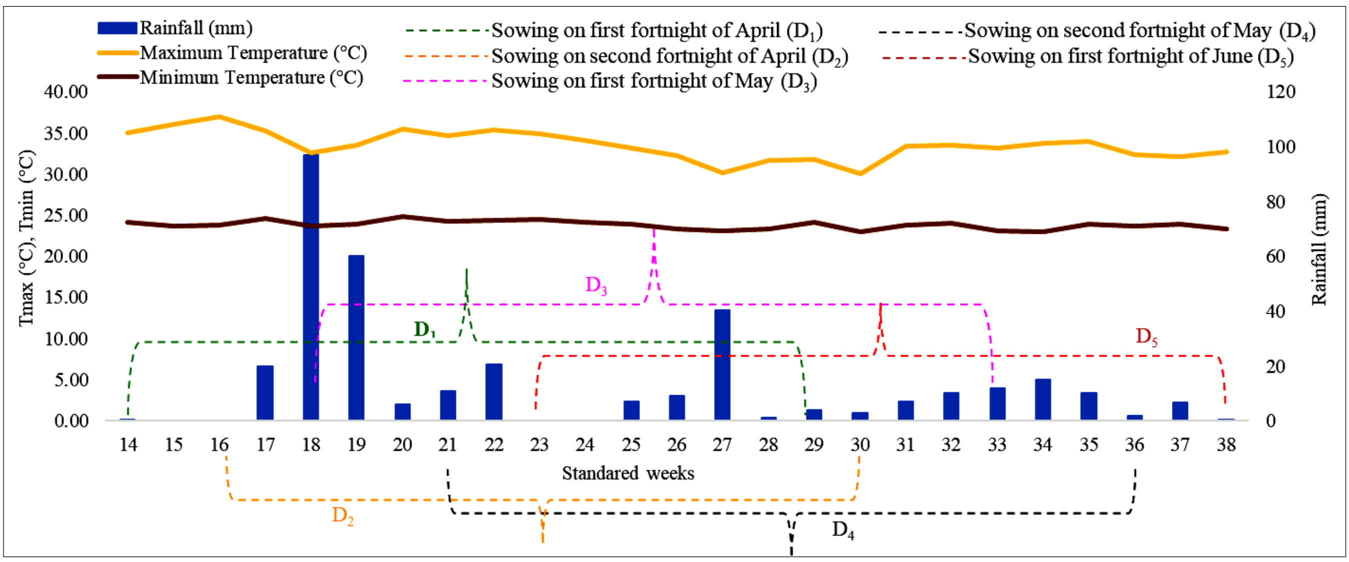

Fig. 1. Weather variables recorded during the cropping period 2023 at TNAU, Coimbatore.

period at different sowing dates is presented in Fig. 1. The crop biometric observations were collected at the appropriate growth stages of the crop and the data were statistically analysed through Fisher's method (13). All the parameters were subjected to analysis of variance (ANOVA) and were analysed with AGRES statistical software. The economics of cultivation was worked out based on the input cost and Minimum Support Price (MSP) of sorghum prevailed at the time of experimentation for all the treatments.

Results and Discussions

Sowing windows and nitrogen levels on growth attributes of sorghum

Sorghum growth attributes such as plant height (cm) and Dry Matter Production (DMP) (Kg ha^{-1}) at harvest stage, Leaf Area Index (LAI) at flowering stage were presented in Table 1. The results indicated that sowing dates and nitrogen levels significantly influenced the growth attributes of sorghum variety K 12 during the summer irrigated conditions.

Plant height

Plant height is a direct measure of the vigour and growth of the plant. Generally, the plant height is gradually increased from the seedling stage and reaches its maximum at the harvest stage. From the present investigation, all the growth attributes of sorghum have decreased in advanced sowing compared with delayed sowing in the summer season of 2023. The results revealed that at harvest stage significantly higher the plant height (257 cm) was observed on first fortnight of June (D_5) sowing and it was on par with second fortnight of May (D_4) sowing. The minimum plant height (232.2 cm) was noticed in the first fortnight of April (D_1) sown crop, which was on par with the second fortnight of April (D_2) (238 cm). This reduced plant height in early sown sorghum may be due to the prevalence of unfavourable weather conditions throughout the crop growth phases that put the crop prone to water and nutrient stress due to high temperature and low rainfall in the cropping period (14). Delayed sowing experienced favourable climatic circumstances compared to the early sown sorghum in terms of temperature and other climatic indicators during various crop growth stages, which enhanced the efficient utilization of all the available resources that mainly determine the greater growth of the plants (15). With respect to nitrogen levels significantly higher the plant height (252.1cm) was observed the application of 125 % of the recommended dose of nitrogen (N_3) and the lower plant height (238 cm) was observed the application of 75 % of the recommended dose of nitrogen (N_1) levels. Due to higher supply of nitrogen results in production of more auxin that could attribute to apical dominance and cell elongations thus leading to beneficial effect and better growth of the plant (16). An enhanced nitrogen supply led to higher carbohydrate utilisation, resulting in the production of more protoplasm and other cellular components rather than their deposition, which thickened the cell wall that resulted in increased the plant height (17). The interaction effect showed that there was no statistically significant difference between different dates of sowing and nitrogen levels on plant height harvest stages of sorghum.

Table 1. Sowing windows and nitrogen levels on growth attributes of sorghum.

Treatments	Plant height at harvest stage (cm)	LAI at flowering stage	DMP at harvest stage (Kg ha^{-1})
Sowing windows			
D_1 - First fortnight of April	232.2	7.40	13147.6
D_2 - Second fortnight of April	238.0	7.79	13915.2
D_3 - First fortnight of May	244.2	8.12	14392.7
D_4 - Second fortnight of May	251.1	8.44	15382.2
D_5 - First fortnight of June	257.0	8.54	14837.1
SEd	5.40	0.172	465.15
CD (P=0.05)	12.46	0.396	1072.65
Nitrogen levels			
N_1 - 75 % RDN (67.5 kg N ha^{-1})	238.0	7.81	13106.7
N_2 - 100 % RDN (90 kg N ha^{-1})	243.4	8.07	14386.7
N_3 - 125 % RDN (112.5 kg N ha^{-1})	252.1	8.30	15511.4
SEd	4.08	0.150	336.64
CD (P=0.05)	8.50	0.313	702.21
Interaction (D×N)			
SEd	9.20	0.323	770.79
CD (P=0.05)	NS	NS	NS

Leaf Area Index (LAI)

LAI is an important parameter to access the total assimilating area of the leaf and determine the source availability for the translocation of photosynthates to sink. Generally, the LAI increased linearly and reached its maximum at the flowering stage. With respect to various dates of sowing sorghum, the crop sown on the first fortnight of June (D_5) recorded significantly higher the LAI (8.54) and it was on par with second fortnight of May (D_4) (8.44). The lower LAI (7.40) was noticed in the early sowing of sorghum on first fortnight of April (D_1). Due to the favourable temperature and good amount of rainfall during the entire crop growth period at delayed sowing of sorghum enhanced the LAI (18). Reduced LAI was noticed in the advanced sowing of sorghum. In the summer season, the rate of leaf initiation gets affected owing to increased temperature and decreased individual leaf expansion rates, resulting in a lower LAI during the growth stages (19). Application of 25 % excess nitrogen from the recommended dose of nitrogen (N_3) registered maximum LAI (8.30) at flowering stage. The minimum LAI (7.81) was recorded with the reduced level of the 75 % recommended dose of nitrogen (N_1) application. With adequate supply of nitrogen, the plant cells produced tend to be large with thin wall which results in increasing the photosynthesing area (leaf size) (20). Higher rate of nitrogen with split application may lead to efficient recovery of the nutrients by roots and thereby enhanced leaf area of the plant and resultant increase in the LAI (21). There was no significant interaction effect found on sorghum LAI with respect to dates of sowing and nitrogen levels.

Dry matter production

The efficient utilization of available resources is only reflected in dry matter production. The dry matter production increased linearly and reaches maximum at the harvest stage of the crop. Sorghum sowing on the second fortnight of May (D_4) recorded a significantly maximum dry matter production (15382.2 kg ha^{-1}) was on par with the first fortnight of June (D_5) (14837.1 kg ha^{-1}) and the first fortnight of May (D_3) (14392.7 kg ha^{-1}). The lowest dry matter production (13147.6 kg ha^{-1}) was noticed in the first fortnight of April (D_1) on par with the second fortnight of April (D_2) (13915.2 kg ha^{-1}). This increase in dry matter yield with delay in sowing could be attributed to the exploitation of favourable climatic conditions by the plants at the important growth stages and higher LAI in the delayed sowing might have contributed to more dry matter production by enhancing the photosynthetic rate (22). Reduced dry matter production was observed in the early sowing of sorghum. This might be since the increased temperature in advanced sowing hastened maturity, shortened crop duration and reduced the ability of plants to accumulate sufficient photosynthates, resulting in poor vegetative growth and ultimately reduced dry matter production (23). The rise in temperature during crop growth period resulted in more transpiration losses and reduced the growth rate and consequently reduced dry matter accumulation (24). At the same time, an increased level of the 125 % recommended dose of nitrogen (N_3) registered higher dry matter production (15511.4 kg ha^{-1}) and the minimum dry matter production (13106.7 kg ha^{-1}) was observed under the 75 % of recommended dose of nitrogen (N_1) at the harvest stage. Nitrogen application enhances the vegetative growth which contribute to more leaf area as observed and thus higher LAI in sorghum (25). Increased nitrogen application can increase the LAI and photosynthetic efficiency that led to more accumulation of more dry matter production (26). The dry matter production of sorghum was not significantly influenced by the interaction of sowing dates and nitrogen levels.

Sowing windows and nitrogen levels on yield attributes and yield of sorghum

Yield attributes

The yield attributing characters of sorghum variety K 12 significantly varied with the different dates of sowing and the nitrogen levels under summer irrigated conditions. The influence of the various treatments on yield attributing characters such as ear head length (cm), ear head weight (g), number of grains earhead^{-1}, test weight (g), grain yield (kg ha^{-1}) and stover yield (kg ha^{-1}) are presented here under Table 2.

At the time of harvest, a significantly maximum ear head length (23.3 cm) was noticed in the sowing of the first fortnight of June (D_5) and this was on par with the sowing of the second fortnight of May (D_4) (22.8 cm). In contrast, a reduced ear head length (20.1 cm) was recorded in the sowing of the first fortnight of April (D_1) which was observed to be on par with the second fortnight of April (D_2) (20.8 cm). At the same time higher the ear head weight (63.8 g), number of grains ear head^{-1} (1274) and test weight (32.9 g) was recorded in the sowing on the second fortnight of May (D_4) sowing followed by first fortnight of May (D_3) sowing (60 g, 1200 & 30.4 g). Lower the earhead weight (48.6 g), number of grains earhead^{-1} (1045) and test weight (23.8 g) was observed sorghum sown on first fortnight of June (D_5) sowing. Delayed sowing realized higher yield attributes than the rest of the sowing and it was associated with the stronger source sink relationship. This might be owing to better growth conditions such as temperature, light and rainfall to fully exploit the genetic potential of the crop (27). Under the early sowing of first fortnight of April (D_1) conditions the prevailed weather might have hindered the accumulation of sufficient photosynthates due to the reduced vegetative growth and reduce the yield attributes and yield (28). The prolonged photoperiod in delayed sowing and favourable

Table 2. Sowing dates and nitrogen levels on yield attributes and yield of sorghum.

Treatment	Ear head length (cm)	Ear head weight (g)	Number of grains ear head^{-1}	Test weight (g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Sowing windows						
D_1 - First fortnight of April	20.1	53.9	1102	26.6	3649.5	10720.7
D_2 - Second fortnight of April	20.8	57.3	1149	28.4	3837.7	11073.7
D_3 - First fortnight of May	21.5	60.0	1200	30.4	3978.1	11328.2
D_4 - Second fortnight of May	22.8	63.8	1274	32.9	4230.3	11994.3
D_5 - First fortnight of June	23.3	48.6	1045	23.8	3404.2	12225.6
SEd	0.47	1.65	21.0	0.94	109.81	221.87
CD (P=0.05)	1.08	3.81	48.4	2.17	253.22	511.63
Nitrogen levels						
N_1 - 75 % RDN (67.5 kg N ha^{-1})	19.3	48.0	1075	25.2	3556.7	10636.5
N_2 - 100 % RDN (90 kg N ha^{-1})	21.8	55.9	1155	28.6	3839.5	11453.6
N_3 - 125 % RDN (112.5 kg N ha^{-1})	23.9	66.2	1232	31.5	4063.6	12315.5
SEd	0.50	1.25	14.6	0.60	90.11	144.57
CD (P=0.05)	1.05	2.60	30.5	1.26	187.96	301.57
Interaction (D×N)						
SEd	1.03	2.81	34.0	1.45	197.79	344.81
CD (P=0.05)	NS	NS	NS	NS	NS	NS

environmental conditions at all the phenophases might have promoted the vegetative growth of the plant that enhance the better source sink relationship which resulted higher yield attributes and yield. (29).

Each successive rate of nitrogen levels increased by 25 % from a reduced level (75 % recommended dose of nitrogen) up to an increased level (125 % recommended dose of nitrogen) showed a noticeable increase in the ear head length of the sorghum K 12 variety under summer irrigated conditions. Among the nitrogen levels significantly higher the ear head length (23.9 cm), ear head weight (66.2 g), number of grains ear head^{-1}(1232) and test weight (31.5 g) was recorded with the application of an increased level of the 125 % recommended dose of nitrogen (N_3). Meantime lowers the ear head length (19.3 cm), ear head weight (48 g), number of grains earhead^{-1} (1075) and test weight (25.2 g) was observed in the reduced level of the 75 % recommended dose of nitrogen (N_1) application. The response of sorghum to applied nitrogen might be ascribed to the favourable effect of nitrogen on yield and yield attributing characters. This might be because nitrogen increased the availability of nutrients that supported growth and development of crop and increase the sink size which would eventually support further increase in yield attributes and yield (30). About the interaction effect between the sowing dates and the nitrogen levels, there was no statistically significant effect in yield attributes of summer irrigated sorghum.

Grain yield

Among the different sowing windows crop sown on the second fortnight of May (D_4) produced the significantly highest grain yield (4230.3 kg ha^{-1}) followed by the first fortnight of May (D_3) (3978.1 kg ha^{-1}). The lowest grain yield (3404.2 kg ha^{-1}) was obtained from the first fortnight of June (D_5) sown crop. The yield increase of 15.9 % was observed in the sowing done on second fortnight of May (D_4) compared to first fortnight of April (D_1) (3649.5 kg ha^{-1}). Sowing dates have greater effect on the sorghum yield which might increase the LAI, promote better growth period, length of the panicle thus subsequently increasing the weight of the grains per plant. Delayed sowing realized higher yield attributes and yield than the rest of the sowing and it was associated with the stronger source sink relationship. This might be owing to better growth conditions such as temperature, light and rainfall to fully exploit the genetic potential of the crop (31). Under the early sowing of first fortnight of April (D_1) conditions the prevailed weather might have hindered the accumulation of sufficient photosynthates due to the reduced vegetative growth (32). Though the growth attributes were higher in the crop sown on first fortnight of June (D_5), exposure to high rainfall intensity around 120.6 mm (Fig. 1) at the time of anthesis to grain filling stage leads to poor pollination due to the shedding of pollens from the panicle that ultimately reflected on yield reduction by poor grain filling and has resulted in reduced productivity. As sorghum is the short-day plant, the advanced sowing at the peak summer season will force the crop to enter the reproductive phase without attaining proper vegetative growth which ultimately affecting the yield attributing character and yield (33).

Regrading to the nitrogen levels, the application of an increased level of the 125 % recommended dose of nitrogen (N_3) registered the statistically highest grain yield (4063.6 kg ha^{-1}) This showed an increase of 5.8 % in grain yield compared to the 100 % recommended nitrogen level (N_2). The lowest grain yield (3556.7kg ha^{-1}) was recorded at the reduced level of the 75 % recommended dose of nitrogen (N_1) application. The grain yield of sorghum mainly determined by number of grains panicle^{-1} and test weight. The number of grains is determined during the early part of the plant growth cycle (panicle initiation, gametogenesis and anthesis), while the grain weight is mainly driven by the post flowering process. It was found that the sorghum grain yield was increased with an increase in nitrogen application which attributed to increased grain number (34). It is evident from the results that plants applied with higher dose of nitrogen yielded maximum. This increased nitrogen levels could aid in active and extended periods of photosynthesis that tend to enhance the number of grains panicle^{-1} and highest test weight (35). The interaction effect of sowing and nitrogen levels was found to be statistically not significant on sorghum grain yield.

Stover yield

The considerable effect of date of sowing could be noticed in the crop sowing on the first fortnight of June (D_5) registered a significantly higher stover yield (12225.6 kg ha^{-1}) and it remained on par with the second fortnight of May (D_4) sown crop (11994.3 kg ha^{-1}). The lowest stover yield (10720.7 kg ha^{-1}) was obtained from the crop sown on the first fortnight of April (D_1). The prolonged photoperiod in delayed sowing and favourable environmental conditions at all the pheno-phases might have promoted the vegetative growth of the plant resulted in higher the stover yield (36). Regarding the effect of nitrogen levels, the application of an increased dose of 125 % recommended dose of nitrogen (N_3) recorded the highest stover yield (12315.5 kg ha^{-1}) while the lowest stover yield (10636.5 kg ha^{-1}) was obtained with the application of a reduced dose of 75 % recommended dose of nitrogen (N_1). This response of sorghum to nitrogen application might be attributed to the favourable influence of nitrogen on crop development in terms of plant height, leaf area and dry matter accumulation plant^{-1}. Nitrogen is a component of porphyrins in chloroplast, higher the nitrogen fertilisation higher will be the crop growth, grain yield and stover yield (37). The interactive effect of the dates of sowing and the nitrogen levels showed no significant difference in the sorghum stover yield.

Sowing windows and nitrogen levels on economics of sorghum

The economic evaluation indicated that different dates of sowing with nitrogen levels have similar cost of cultivation. However, the economic returns were differed due to variation in sorghum grain yield obtained from different treatments (Fig. 2). The maximum cost of

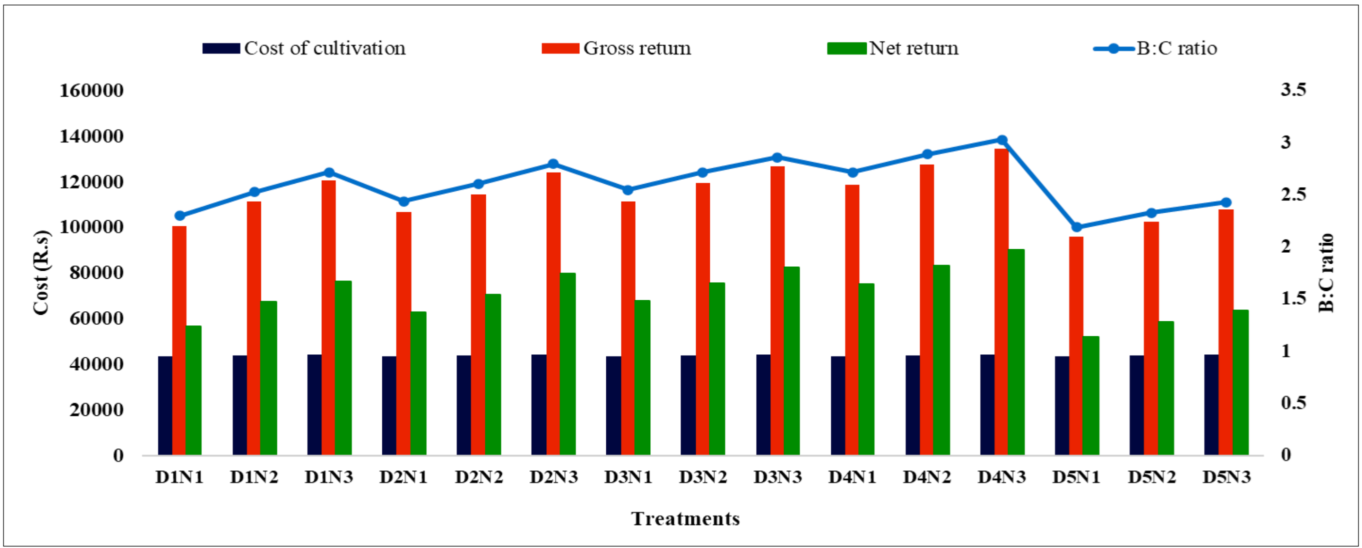

Fig. 2. Sowing windows and nitrogen levels on economics of sorghum.

cultivation was incurred in excess application of 125 % recommended dose of nitrogen (N3) (Rs. 44432 ha^{-1}) followed by 100 % recommended dose of nitrogen (N2) (Rs. 44030 ha^{-1}) application. This highest cost was mainly due to increased fertilizer application necessary for imposing the treatment. The total income was calculated based on the MSP for sorghum, announced by the Government of India in 2023, along with the yield and is expressed in rupees per hectare. Maximum gross return (Rs. 134424 ha^{-1}), net return (Rs. 90100 ha^{-1}) and B:C ratio (3.03) was obtained in crop sown on second fortnight of May (D_4) combined with increased level of 125 % RDN (N_3), the treatment combination is D_4N_3. The highest net return from this treatment combination might be due to the receipt of maximum gross return or benefits gained surpasses the additional amount incurred towards input cost than other treatments. Superior yield attributes and the maximum grain yield were the major reason for higher gross return, net return and B:C ratio. Reduced gross return (Rs. 100597 ha^{-1}), net return (Rs. 56861 ha^{-1}) and B:C ratio (2.30) was observed in first fortnight of sowing (D_1) with reduced level of 75 % RDN (N_1) *i.e.*, the D_1N_1 treatment combination. Highest cost of cultivation and the lowest economic yield are the main reasons for reduced economic returns (38).

Conclusion

Based on the above results and finding it could be concluded that the sorghum growth attributes, yield attributes and yield were higher in delayed sowing in combined with increased level of nitrogen application compared to the other sowing dates and nitrogen levels. It is therefore recommended that sorghum variety K 12 sown on second fortnight of May (D_4) along with increased level of 125 % recommended dose Nitrogen (N_3) recorded higher yield with higher economic return under summer irrigated condition in the western agroclimatic zone of Tamil Nadu.

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Authors' contributions

AA performed the execution, experimentation, analysis, manuscript writing and editing. Idea generation, supervision and reviewing was done by VG. The data curation, data analysis using R software, plot creation was done by KB. MKK supervises field experiments, guidance and reviewing. Conceptualization, guidance and reviewing was done by NT. MP performed the guidance and reviewing.

Compliance with ethical standards

Conflict of interest: The authors declare no conflicts of interest regarding the publication of this research article.

Ethical issues: None

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