Int.J.Curr.Microbiol.App.Sci (2020) *9*(4): 3243-3251

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 9 Number 4 (2020)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2020.904.377

Effect of Sowing Dates on Growth and Yield of Foxtail Millet (*Setaria italica* L.) Varieties

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Keywords

Foxtail millet, Varieties, Dates of sowing, Growth, Yield, Economics

Article Info

Accepted:
30 March 2020
Available Online:
10 April 2020

A B S T R A C T

A field experiment was conducted during *Kharif*, 2017 at Regional Agricultural Research Station, Jagtial with three varieties (SiA 3156, SiA 3085 and Suryanandi) in combination with four dates of sowing (10^{th}, 20^{th} 30^{th} August and 10^{th} September). The results revealed that the variety SiA 3085 recorded significantly higher stature of growth, yield attributes and yield. The above parameters were at their lower level with the variety Suryanandi. The crop sown on 30^{th} August performed significantly higher stature of plant growth parameters; yield attributes and yields, while they were found to be at their lower level when sown on 10^{th} September. The results concluded that sowing of foxtail millet variety SiA 3085 up to last fort night of August was profitable to the farmers in sandy loam soils of Northern Agro-climatic zone of Telangana.

Introduction

Foxtail millet or Italian millet (*Setaria italica* L.) is one of the oldest and second most cultivated small millets for food and fodder. It is known for its drought tolerance (Cheng and Liu, 2003) and can withstand severe moisture stress and also suited to wide range of soil conditions. Foxtail millet has an excellent nutritional profile and is miles ahead of rice and wheat in terms of protein, fibre, minerals and vitamins. It is rich in dietary fibre (6.7%), protein (11%), and low in fat (4%). Unlike rice, foxtail millet releases glucose steadily without affecting the metabolism of human body. Hence, it is recognized as diabetic food. As the consumption of foxtail millet is increasing day by day particularly by the people suffering with diabetes, there is an increasing demand for foxtail millet (Hariprasanna, 2006).

In India foxtail millet is grown in an area of 98,000 ha producing about 56,000 tons of grain with an average productivity of 565 kg ha^{-1}(Department of Agriculture and Cooperation, Ministry of Agriculture, GOI, 2014). Andhra Pradesh, Karnataka, Tamilnadu are the major foxtail millet growing states contributing about 90 % of the total area under cultivation. Combined Andhra Pradesh alone contributed for about 79% of the total area under foxtail millet. In Telangana State, foxtail millet is mostly grown in Mahbubnagar and Rangareddy districts (Hariprasanna, 2006).

The yield potential of foxtail millet is very low because of conventional cultivation of low yielding cultivars, inadequate application of fertilizers and lack of good management practices. New short duration varieties of SIA 3085 and SIA 3088 are becoming popular. They have a yield potential of 20-25 q ha^{-1}(AICSMIP, 2015).There is a good scope for increase in area under foxtail millet because of the new opportunities and new varieties.

During the present days of climatic change, high energy farming is slowly replaced with low energy traditional farming with climatic resilient crops like small millets for conservation and to aid in making sound and stable management under increasing evidence of less seasonal rainfall, increase in temperature and frequent occurrence of extreme weather events. Under such situations foxtail millet is best suited as it is of short duration, known for its drought tolerance and can withstand severe moisture stress and also suited to wide range of soil conditions with high energy use efficiency. In the present context of climate change and recurrent aberrant weather conditions, foxtail millet can be grown as a contingent crop (PJTSAU, 2015-16).

Experimental evidence regarding the optimum date of sowing for improved foxtail millet varieties under rainfed conditions is lacking for Northern Agro climatic zone of Telangana. Hence, promising foxtail millet varieties were tested for their response to dates of sowing to evaluate their yield potentiality.

Materials and Methods

In order to study the effect of sowing dates on growth, yield and economics of foxtail millet varieties, an experiment was conducted during *kharif*, 2017 at Regional Agricultural Research Station, situated in the same campus of Agricultural College, PJTSAU, Polasa, Jagtial, Telangana State. The experiment was laid out in Randomized block design with factorial concept (FRBD) and it was replicated thrice. Three varieties *viz.*, SiA 3156, SiA 3085 and Suryanandi in combination with four dates of sowing *viz.*, 10^{th}, 20^{th} 30^{th} August and 10^{th} September was adopted, thus a total of 12 treatments were imposed. The soil of the experiment site was sandy loam in texture, having slightly alkaline (pH 8.21), normal in salinity (EC 0.159 d Sm^{-1}), medium in organic carbon content (0.85 %), low in available N (220 kg ha^{-1}), high in available phosphorus (28.23 kg ha^{-1}) and medium in available potassium (249.0 kg ha^{-1}). Recommended dose of N, P and K (40-30-0 kg ha^{-1} N, P_2O_5 and K_2O) was applied to all plots in the form of Urea and SSP. The crop was sown in lines at 30 × 10 cm spacing. The crop was sown on 10^{th}, 20^{th}, 30^{th} August and 10^{th} September, 2017. The time of harvesting varied from 75-90 days after sowing, depending upon the varietal duration.

Results and Discussion

Performance of varieties under different dates of sowing

Final plant population of foxtail millet was significantly influenced by different varieties as well as sowing dates, while their interaction effect was not significant (Table 1).

The final plant population of 31, 29 and 28 m^{-2} was registered with the variety SIA 3085 (C_2), SIA 3156 (C_1) and Suryanandi (C_3), respectively. Similarly final plant population of 32, 31, 28 and 27 m^{-2} recorded on D_3, D_2, D_1 and D_4 (Sowing on 30^{th}, 20^{th}, 10^{th} August and 10^{th} September) respectively.

Variety Suryanandi showed decreased final plant stand as compared to SiA 3085 and SiA 3156, indicating increased mortality of seedling on 10^{th} August due to heavy rainfall,

more humidity and excessive wet soil condition from sowing to tillering stage and on 10th September less rainfall coupled with extreme temperature and low soil moisture caused less plant stand per metre square area. These results are in line with the findings of Mahendra Singh *et al.,* (1975)

Plant height recorded at harvest was significantly influenced by different varieties and dates of sowing, whereas the interaction between varieties and sowing dates was found to be non-significant.

Significantly superior plant height (120.4 cm) was recorded with SiA 3156 (C_1) which was on par with SiA 3085 (C_2).The variety Suryanandi (C_3) produced the shortest plant height (105.4 cm). The difference in plant height among the varieties might be due to the variation in their genetic character and inter nodal length. The above results are in confirmity with the findings of Navya Jyothi *et al.,* (2015).

Similarly, significantly highest plant height (120.7 cm) was recorded with D_3 (sowing on 30th August), which was significantly on par with D_2 (sowing on 20th August) which in turn comparable with D_1 (sowing on 10th August). While the shorter plants (108.9 cm) were registered on D_4 (sowing on 10th September). Similar findings were in line with the findings of Umashanker Lal (1982) and Dubey *et al.,* (1993).

The total number of tillers m^{-2} recorded at harvest was significantly influenced by different varieties and dates of sowing. While the interaction between varieties and sowing dates was found to be non-significant (Table 1).

Significantly superior number of tillers m^{-2} (93) was recorded with SiA 3085 (C_2) followed by SiA 3156 (C_1) (90) and significantly inferior number of tillers m^{-2} (79) was obtained with the variety Suryanandi (C_3). The above results are in conformity with the findings of Navya Jyothi *et al.,* (2015).

The highest number of tillers m^{-2} (100) was recorded with D_3 (sowing on 30th August), which was comparable (97) with D_2 (sowing on 20th August). Similarily highest number of tillers m^{-2} (81) recorded with D_1 (sowing on 10th August) was comparable with D_4 (sowing on 10th September) (72).

Dry matter production of foxtail millet showed an increasing trend with advance in age of the crop up to maturity (Table 1). Dry matter production of foxtail millet varied significantly due to varieties and dates of sowing, while the interaction effect was found to be non-significant.

Among the varieties significantly superior dry matter (354.1 g m^{-2}) was accumulated with the variety SiA 3085 (C_2) followed by SiA 3156 (C_1) (324.8 g m^{-2}) and Suryanandi (C_3) (283.8 g m^{-2}) respectively. This could be mainly attributed to increase in plant height and leaf area due to their genetic makeup. The increase in the assimilatory surface area per plant might have caused an increase in its biomass, which ultimately lead to the accumulation of a large quantity of photo assimilates. This is in accordance with the results reported by Intodia (1994), Saini and Thakur (1997) and Raghavendra and Halikatti (1998).

Among the dates of sowing significantly highest dry matter (356.0 g m^{-2}) was recorded with D_3 (sowing on 30th August) which was on par (349.3 g m^{-2}) with D_2 (sowing on 20th August) and it was at par (347.4 g m^{-2}) with D_1 sowing date (sowing on 10th August). These treatments significantly superior (231.0 g m^{-2}) over D_4 (sowing on 10th September). The highest dry matter production recorded on 20th and 30th August could be attributed to the

cumulative effect of increased plant height, maximum number of tiller production and the crop had an opportunity of longer growth period with sufficient light, temperature, relative humidity, bright sunshine hours coupled with optimum day length which might have increased photosynthesis, in turn, dry matter production and yield. On the other hand delay in sowing during 10th September resulted in negetative phase coinciding with short day periods resulting in lower biomass accumulation and in turn lower yield. Similar findings were observed with Revathi *et al.*, (2017).

Number of panicles m^{-2} at harvest was significantly influenced by varieties and dates of sowing. While, the interaction between varieties and dates of sowing was found non-significant (Table 1)

The highest number of panicles m^{-2} **(**86.7**)** was recorded with the variety SiA 3085 which was significantly on par with SiA 3156 (83 panicles m^{-2}**)** and both of these varieties were significantly superior to that of the Suryanandi (75.7 panicles m^{2}**)**. This might be due to the genetic potential of the variety to produce more number of tillers m^{-2} and then converted to more number of productive tillers m^{-2}.

The highest number of panicles m^{-2} (95.3) was recorded with D_3 (sowing on 30th August) which was significantly on par (90.9) with D_2 (sowing on 20th August). Next best treatment 75.1 panicles m^{-2} recorded with D_1 (sowing on 10th August) which was at par (66) with D_4 (sowing on 10th September). Crop sown on D_3 received well distribution of rain fall and bright sunshine hours might have contributed in getting good yields. Though the earliest crop received good amount of rainfall less productive tillers m^{-2} were produced due to more humidity in atmosphere as well as excess soil moisture caused lodging of crop, more prone to disease infestation and seed mortality. The late planted crop is subjected to relatively lesser time span available for plant growth and development. Our findings confirm the results of Umashanker Lal (1982), Dubey *et al.*, (1993) and Upadhayay *et al.*, (2001).

The panicle length of foxtail millet was significantly influenced by different varieties and dates of sowing, while the interaction effect was non-significant (Table 2).

The variety SIA 3085 (C_2) recorded significantly superior panicle length (20.5 cm). The next best variety is SIA 3156 (C_1) with panicle length of (17.6 cm) and it was at par (16.3 cm) with Suryandi (C_3). This might be due to the genetic potential of the variety in deciding the length of the panicle and in better partitioning of assimilates from source to sink. Similar results were obtained by Intodia (1994) and Saini and Negi (1996) and Navya Jyothi *et al.*, (2015).

Significantly on par ear head length of (20.5 and 19.7 cm) recorded on sowing dates of D_3 (Sowing on 30th August) and D_2 (Sowing on 20thAugust) respectively. Followed by higher ear head length of (17.2 cm) recorded in D_1 (Sowing on 10thAugust) which was statistically nearer to D_4 (sowing on 10th September).

Number of grains ear $head^{-1}$ of foxtail millet was significantly influenced by different varieties and dates of sowing, while the interaction effect was non-significant (Table 2).

Among varieties tested, the highest number of filled grains ear $head^{-1}$ (1386) was obtained with the variety SIA 3085 (C_2) which was comparable (1255) with that of variety SIA 3156 (C_1).Significantly lowest number of filled grains ear $head^{-1}$ (898) was produced by the variety Suryanandi (C_3).

Table.1 Effect of sowing dates on growth parameters foxtail millet varieties

Treatment	Final plant population (m^{-2})	Plant height (cm)	No. of tillers m^{-2}	Dry matter accumulation (g m^{-2})	No. of panicles m^{-2}
Varieties					
C1: SiA 3156	29	120.4	90	324.8	83.0
C2: SiA 3085	31	117.5	93	354.1	86.7
C3: Suryanandi	28	105.4	79	283.8	75.7
SEm±	**1.03**	**1.66**	**2.68**	**11.43**	**2.49**
CD (P = 0.05)	**3.0**	**4.9**	**7.9**	**33.7**	**7.4**
Sowing dates					
S_1: 10thAugust	28	111.3	81	347.4	75.1
S_2: 20thAugust	31	115.6	97	349.3	90.9
S_3: 30thAugust	32	120.7	100	356.0	95.3
S_4: 10th September	27	108.9	72	231.0	66.0
SEm±	**1.18**	**1.91**	**3.09**	**13.20**	**2.88**
CD (P = 0.05)	**3.5**	**5.6**	**9.1**	**38.9**	**8.5**
Interaction					
SEm±	**2.05**	**3.32**	**5.36**	**22.86**	**4.98**
CD (P = 0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)	**12.6**	**5.39**	**11.3**	**13.3**	**11.3**

Table.2 Effect of sowing dates on yield attributes and yields of foxtail millet varieties

Treatment	Length of ear head (cm)	No. of grains per ear head	Test weight (g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	B: C ratio
Varieties						
C1: SiA 3156	17.6	1255	2.7	1151	2318	1.67
C2: SiA 3085	20.5	1386	2.9	1317	2584	1.95
C3: Suryanandi	16.3	898	2.5	951	2213	1.42
SEm±	**0.71**	**38.18**	**0.09**	**59.87**	**98.52**	**0.09**
CD (P = 0.05)	**2.1**	**112.0**	**0.9**	**175.7**	**289.0**	**0.3**
Sowing dates						
S_1: 10thAugust	17.2	1201	2.6	1063	2384	1.54
S_2: 20thAugust	19.7	1273	2.8	1228	2663	1.83
S_3: 30thAugust	20.5	1479	3.0	1300	2848	1.94
S_4: 10th September	15.1	765	2.4	968	1591	1.42
SEm±	**0.82**	**44.11**	**0.11**	**69.13**	**113.76**	**0.10**
CD (P = 0.05)	**2.4**	**129.3**	**0.3**	**202.8**	**333.6**	**0.3**
Interaction						
SEm±	**1.42**	**76.41**	**0.19**	**119.75**	**197.05**	**0.18**
CD (P = 0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)	**13.9**	**11.2**	**9.7**	**18.2**	**14.4**	**12.3**

Higher number of filled grains panicle^{-1} with SIA 3085 (C_2) might be due to efficient translocation of photosynthates from source to the sink and also the genetic potential of variety. This is in the accordance with the results reported by Divya and Maurya (2013) and Navya Jyothi *et al.,* (2015).

Among different sowing dates, the significantly highest number of filled grains ear head^{-1} (1479) was recorded on D_3 (sowing on 30th August) followed by (1273 grains ear head^{-1}) on D_2 (sowing on 20th August) which was comparable with (1201 grains ear head^{-1}) on D_1 (sowing on 10th August). Significantly inferior number of filled grains ear head^{-1} (765) was recorded with D_4 (sowing on 10th September). The experiment results revealed that highest number of grains ear head^{-1} was recorded on last fort night of August. This may be due to optimum date of sowing as contingent crop and with optimum plant population provides favourable micro climate to crop for effective utilization of available moisture and nutrients leading to better partitioning of photosynthates to reproductive parts might be the reason of getting higher yield attributes. These results are in line with the findings of Anitha *et al.,* (2015).

Test weight of foxtail millet was found to be influenced by different varieties and dates of sowing while the interaction effect was non-significant (Table 2).

Among the varieties tested, test weight of (2.9 g) was obtained with the variety SiA 3085 (C_2) and (2.7 g) with SiA 3156 (C_1) they were significantly on par and in turn SiA 3156 (C_1) is at par with test weight of Suryanandi (C_3) (2.5 g).

Among different sowing dates, the significantly highest test weight (3.0 g) was recorded on D_3 (sowing on 30th August) which was comparable (2.8 g) with D_2 (sowing on 20th August). Significantly inferior test weight was recorded in D_4 (sowing on 10th September).

Crop sown on 2nd fort night of August received good amount of rainfall with equal distribution and bright sunshine hours which might have helped better growth of plant, higher production of dry matter which ultimately increased the partitioning of dry matter to ear head and its development. These findings were in line with the findings of Upadhyay *et al.,* (2001), Anitha *et al.,* (2015) and Prathima *et al.,* (2015).

The grain yield and stover yield of foxtail millet was significantly influenced by the varieties and dates of sowing, while the interaction effect was not statistically traceable (Table 2).

The significantly highest grain yield (1317 kg ha^{-1}) was produced by the variety SIA 3085 (C_2) which was on par with the yield (1151 kg ha^{-1}) produced by the variety SIA 3156 (C_1) and both of these varieties were significantly superior to that of the variety Suryanandi (C_3). In turn Suryanandi (C_3) recorded significantly the lowest grain yield (951 kg ha^{-1}). Difference in yields among the varieties can be attributed to their genetic potentiality to utilize and translocate photosynthates from source to sink (Anitha *et al.,* 2015). Dhagat *et al.,* (1977) also reported that in *Itallian millet* (Korra) grain yield was positively correlated with length, weight and grain yield of the main ear head and harvest index. The results were in confirmity with the findings of Munirathnam *et al.,* (2006), Divya and Maurya (2013), Revathi *et al.,* (2015) and Navya Jyothi *et al.,* (2015).

The significantly highest grain yield (1300 kg ha^{-1}) was recorded with D_3 (sowing on 30th August) followed by grain yield of (1228 kg ha^{-1}) in D_2 (sowing on 20th August) and it was

on par with the grain yield of (1063 kg ha^{-1}) in D_1 (sowing on 10th August). Significantly inferior grain yield (968 kg ha^{-1}) was recorded with D_4 (sowing on 10th September).

Among the varieties tested, the highest straw yield (2584 kg ha^{-1}) was obtained with the variety SiA 3085 (C_2) and it was on par with the stover yield of (2318 kg ha^{-1}) with SiA 3156 (C_1) and in turn SiA 3156 (C_1) is at par with stover yield of (2213 kg ha^{-1}) recorded with SiA 3156 (C_1). Genetic makeup of the variety and environmental conditions also contributed to more dry matter production which ultimately increases the stover yield. The similar results were reported by Munirathnam *et al.,* (2006) Divya and Maurya (2013) and Navya Jyothi *et al.,* (2015).

The significantly highest stover yield (2848 kg ha^{-1}) was recorded with D_3 (sowing on 30th August) and was statistically comparable with D_2 yield (2663 kg ha^{-1}) (sowing on 20th August) and in turn D_2 was on par with D_1 (sowing on 10th August) with that of stover yield (2384 kg ha^{-1}). Significantly inferior stover yield (1591 kg ha^{-1}) was recorded with D_4 (sowing on 10th September).

The crop sown in D_3 (30th August) showed significantly higher grain and stover yield. This may be due to good amount and equal distribution of rain fall from sowing to vegetative stage, bright sunshine hours which might have contributed in getting good yields. In first fortnight of August planting (D_1) less yield was observed than second and third fortnight. This is because high rain fall intensity, lower temperature and higher humidity from flowering to reproductive stage caused more disease infestation, shedding of inflorescence, poor grain setting which finally reduced the grain productivity (Mahendra Singh *et al.,* 1975). Late sown crop experienced extreme moisture stress during seedling and ear head emergence period which drastically reduced the final plant stand (Mahendra Singh *et al.,* 1975) and partitioning of dry matter to ear head and its development could not be received even with sufficient moisture conditions later on (Prathima *et al.,* 2015). Thus, sowing of foxtail millet beyond or before its optimum period caused reduction of grain yield. Our findings are in line with the results of Dubey *et al.,* (1993) and Prathima *et al.,* (2015)

Benefit–cost ratio of foxtail millet was significantly influenced by varieties and dates of sowing while the interaction was not statistically traceable (Table 2).

The highest benefit-cost ratio (1.94) was recorded with the variety SIA 3085 (C_2) which was however comparable (1.83) with that of variety SIA 3156 (C_1) and both of these varieties were significantly superior to the variety Suryanandi (C_3) (1.54). Higher grain and straw yields and net returns obtained with variety SIA 3085 (C_2) might be responsible for higher benefit-cost ratio. The present findings corroborates with that of Subramanian and Ganesaraja (1992), Munirathnam *et al.,* (2006) and Navya Jyothi *et al.,* (2015).

The significantly highest Benefit-cost ratio (1.94) was recorded with D_3 (sowing on 30th August) and it was statistically comparable with B: C ratio of 1.83 recorded in D_2 (sowing on 20th August) followed by B: C ratio of 1.54 in D_1 (sowing on 10th August) and it was on par with D_4 (sowing on 10th September). These results are in line with the findings of Upadhay *et al.,* (2001).

From this study, it can be concluded that higher productivity of foxtail millet obtained with cultivation of varieties SiA 3085 and SiA 3156 were suitable when sown up to 30th August as contingent crop.

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How to cite this article:

Srikanya, B., P. Revathi, M. Malla Reddy and Chandrashaker, K. 2020. Effect of Sowing Dates on Growth and Yield of Foxtail Millet (*Setaria italica* L.) Varieties. *Int.J.Curr.Microbiol.App.Sci.* 9(04): 3243-3251. doi: https://doi.org/10.20546/ijcmas.2020.904.377