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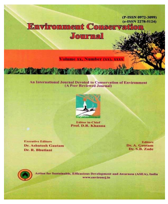

Influence of biostimulants on growth and productivity of foxtail millet (*Setaria italica* L.) genotypes

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ABSTRACT

A field experiment was carried out at AHRS, Bavikere, Karnataka during late *kharif* season of 2021to find out the "Influence of biostimulants on growth and productivity of foxtail millet (*Setaria italica* L.) genotypes''. The field trial was laid out in split plot design with 12 treatment combinations. The study involves three genotypes in the main plot *viz*., SiA-3156 (G_1), HMT-100-1 (G_2) and DHFt-109-3 (G_3). Foliar application of biostimulants in sub plots *viz*., 0.1 % humic acid (F_1), 3 % panchagavya (F_2), 0.1 % humic acid and 3 %panchagavya (F_3) at 30 and 60 days after sowing (DAS) and recommended dose of fertilizer (RDF) as control (F_4). Genotypes and Foliar application of biostimulants exhibited significant variation in growth and yield components of foxtail millet. Among the different genotypes, HMT-100-1 recorded significantly higher plant height (142.00 cm), number of tillers per meter (81.87) and leaf area (18.40 dm^2/plant) at harvest and also yield components like panicle length (16.60 cm), grain weight per panicle (4.02 g) and grain yield (1701.0 kg/ha) compared to DHFt-109-3 and SiA -3156. In biostimulants, Foliar application of 0.1 % humic acid and 3 % panchagavya recorded significantly higher plant height (142.32 cm), number of tillers per metre (83.75) and leaf area (18.51 dm^2/plant) at harvest and also yield components like panicle length (16.99 cm), grain weight per panicle (4.33 g) and grain yield (1781.2 kg/ha). While, they were found to be at their lowest with application of RDF alone. Interaction between genotypes and biostimulants was also found to be significant in which combination of HMT-100-1 with foliar application of 0.1 % humic acid and 3 %panchagavya recorded significantly higher growth and yield compared to other treatment combinations.

Introduction

The global climate change and extreme weather fluctuations have emerged as the most threatening challenge to agriculture. Under such situation, cultivation of climate smart crops and adaptions of climate resilient practices are the need of the hour. Millets have been discussed as potential alternatives to cereals due to their inherent ability to grow in adverse conditions like low-quality soils, lack of irrigation facilities and abbarent weather conditions. Since, there has been stagnation in the yield of cereals in recent years, it's the time to exploit the underutilized crops *viz*., finger millet, foxtail millet, barnyard millet, little millet, proso millet and brown top millet and kodo millet.

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Among minor millets, foxtail millet (*Setaria italica* L.) is one of the oldest cultivated crop for grain, hay and pasture. It is adapted to a wide range of elevation, soils, and climatic conditions. However, the potentiality of this crop is not fully exploited. The productivity of foxtail millet in India is very low due to the insufficient application of fertilizers, conventional cultivation of low yielding cultivars and lack of good management practices In India, the area under small millets is 4.44 lakh hectare with the production of 3.46 lakh tonnes and productivity of 781 kg/ha. In Karnataka, the area under small millets account for 0.26 lakh hectares with production of 0.20 lakh tonnes and productivity of 778 kg/ha.Agronomic practices *viz.*, use of growth regulators, PGPR and biostimulants *etc.*, are known to improve the yield and quality of the produce in several crops. Further, biostimulants are eco-friendly and it's usage in millets is very meagre.

Hence, they are one of the most innovative and capable solution to address the challenge of increasing foxtail millet productivity. Biostimulants are the materials which contain substances or microorganisms, whose function when applied to plants or the rhizosphere is to boost natural processes to enhance nutrient uptake, nutrient efficiency, tolerance to abiotic stress and crop quality, independent of its nutrient content. Humic substances are heterogeneous organic molecules that form in the soil as by-products of microbial metabolism of dead organic matter. Use of such particles either to the soil or by foliar application alongside sufficient quantity of conventional fertilizers enhances the proficiency of applied chemical fertilizers. Panchagavya is an organic product produced by using different by-products of cow namely dung, urine, milk, ghee, curd and other ingredients.

It is rich in N, P, K, micronutrients and contains various amino acids, vitamins, growth regulators like auxins, gibberellins along with beneficial microorganisms. Foliar application of biostimulants like humic acid, panchagavya *etc.*, at critical growth stages like tillering and flowering stage not only improves the physiological efficiency and plays a significant role in raising the productivity of the crop. The present investigation was taken to study the role of bio stimulants in increasing productivity of foxtail millet.

Material and Methods

The experiment was laid out in split plot design included twelve treatment combinations which are replicated thrice. Genotypes SiA-3156 (G_1), HMT-100-1 (G_2) and DHFt-109-3 (G_3) in main plots. Subplot treatment includes foliar application of biostimulants *viz.*, 0.1 %humic acid(F_1), 3 %panchagavya(F_2), 0.1 %humic acid and 3 %panchagavya(F_3) at 30 and 60 DAS and RDF as control (F_4). The land was well ploughed and harrowed to make a fine seed bed and foxtail millet was sown with spacing of 30 × 10 cm. The crop was commonly supplied with recommended dose of fertilizer in the form of urea (N), Di ammonium phosphate (DAP) and Muriate of potash (MOP) as per the calculated amount to each plot as basal dose at the time of sowing to all the treatments. Foliar application of the biostimulants *viz.*, humic acid and panchagavya was done at 30 and 60 DAS. Protective irrigation was done as per the need of the crop and two hand weeding at 30 and 45 DAS were done to reduce crop-weed competition. Growth parameters *viz.*, plant height(cm), number of leaves per plant, number of tillers per metre row length, leaf area (dm^2/plant) and total dry matter production (g/plant) were recorded at 30, 60 DAS and at harvest in the randomly selected 5 plants in the net plot area. Yield parameters like panicle length (cm), panicle weight (g), grain weight per panicle (g) and test weight (g) are also recorded from those randomly tagged five plants. Panicles in each treatment plots were harvested separately and sun dried for 4 - 5 days in threshing yard. Later panicles from net plot were threshed and grain weight was recorded in kilogram and later converted to kg/ha. The data recorded on various observations on growth, yield and soil parameters were subjected to analysis of variance (ANOVA) as outlined by Gomez and Gomez (1984). The level of significance used in 'F' test was at 5 %.

Study area

The experiment was conducted at Agricultural and Horticultural Research Station, Bavikere, Chikkamagalur district during late *kharif* 2021. It is situated in the Southern Transition Zone (Zone-7) of Karnataka state at 13°42` N latitude and 75°51` E longitude, with an altitude of 695 meters above the mean sea level.The soil of the experimental site was sandy loam in texture with acidic in reaction (6.12), medium organic carbon (0.52%), medium available nitrogen (315.64 kg/ha), medium available phosphorus (50.56 kg/ha) and medium in available potassium (340.58 kg/ha). During the crop growth period *i.e.,* from September 2021 to December 2021 highest rainfall occurred during October (207.6mm) lowest in the December (0 mm). The mean monthly maximum temperature was highest during October (30.5°C), while it was lowest in November (28.2°C). The maximum relative humidity was observed in September (82.7%) and minimum during December (57.3%). The sunshine hours were higher in November (7.9 hrs), while it was lowest in (6.3 hrs).

Results and Discussion

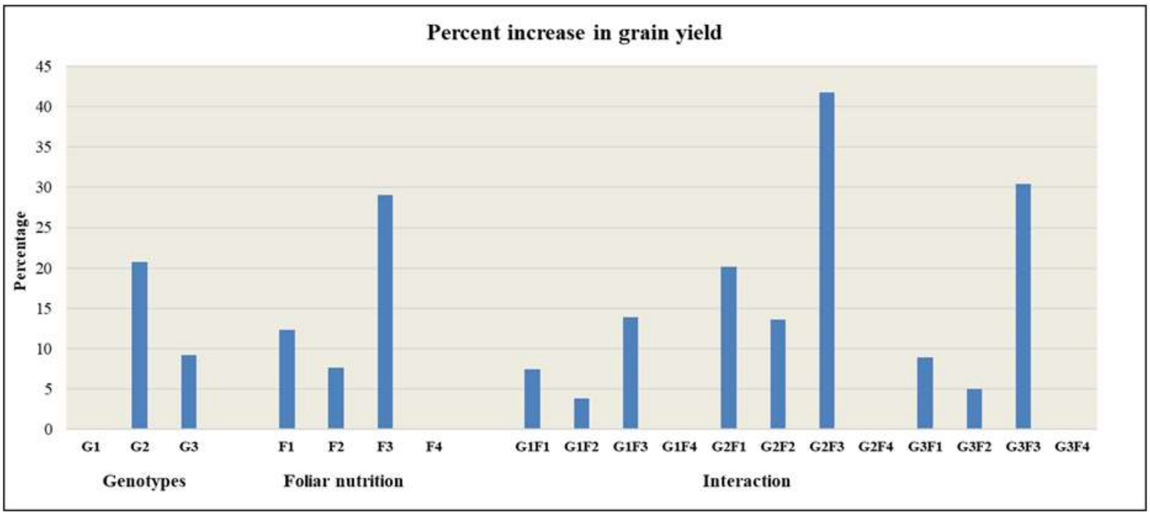
The results of the various growth, yield parameters and productivity of the foxtail millet are tabulated in table 1 - 3 and figure 1.

Table 1: Growth parameters of foxtail millet at harvest as influenced by genotypes and foliar application of biostimulants

Treatments	Plant height (cm)	Number of leaves per plant	Number of tillers per meter row length	Leaf area (dm^2/plant)	Total dry matter production (g/plant)
Main plots – Genotypes(G)					
G_1	131.57	21.17	73.96	15.02	18.03
G_2	142.00	24.20	81.87	18.40	22.33
G_3	136.06	22.24	77.46	16.78	19.08
S. Em. ±	1.86	0.57	1.31	0.35	0.38
C. D. at 5%	7.49	2.25	5.16	1.39	1.52
Sub plots – Foliar nutrition(F)					
F1	136.92	23.27	80.46	17.19	20.64
F2	134.23	20.94	76.67	16.23	18.76
F3	142.32	25.62	83.75	18.51	23.00
F4	132.70	20.32	70.73	15.00	16.85
S. Em. ±	2.12	1.04	0.67	0.41	0.27
C. D. at 5%	6.36	3.10	2.00	1.21	0.81
Interaction (G x F)					
G_1F_1	133.67	23.00	78.37	15.81	17.97
G_1F_2	130.53	20.87	71.22	14.38	17.14
G_1F_3	134.33	26.00	78.93	16.72	21.36
G_1F_4	129.60	20.00	67.23	13.18	15.67
G_2F_1	141.93	28.00	81.18	18.68	23.15
G_2F_2	137.67	25.67	83.00	17.84	22.06
G_2F_3	152.33	31.07	88.98	20.34	25.30
G_2F_4	136.07	24.27	74.41	16.73	18.79
G_3F_1	137.02	27.27	81.65	17.08	20.81
G_3F_2	134.49	23.00	75.52	16.48	17.07
G_3F_3	140.29	30.00	83.53	18.46	22.33
G_3F_4	132.42	22.93	70.53	15.09	16.09
S. Em. ±	3.68	2.26	1.167	0.71	0.47
C. D. at 5%	NS	NS	3.46	NS	1.41

G_1: SiA 3156
G_2: HMT-100-1
G_3: DHFt-109-3

F_1: RDF + Foliar application of humic acid @ 0.1 % at 30 and 60 DAS
F_2: RDF + Foliar application of panchagavya @ 3 % at 30 and 60 DAS
F_3: RDF + Foliar application of humic acid @ 0.1 % and panchagavya @ 3% at 30 and 60 DAS
F_4: RDF (Control)



G_1: SiA 3156
G_2: HMT-100-1
G_3: DHFt-109-3

F_1: RDF + Foliar application of humic acid @ 0.1 % at 30 and 60 DAS
F_2: RDF + Foliar application of panchagavya @ 3 % at 30 and 60 DAS
F_3: RDF + Foliar application of humic acid @ 0.1 % and panchagavya @ 3% at 30 and 60 DAS
F_4: RDF (Control)

Figure 1: Per cent increases in grain yield as influenced genotypes and foliar nutrition of biostimulants.

Among the genotypes, HMT-100-1 recorded significantly higher plant height (142.00 cm), number of leaves/plant (24.20), number of tillers/meter row length (81.67), leaf area (18.40 dm^2/plant) and total dry matter production (22.33 g/plant) at harvest compared to genotype DHFt-109-3 and SiA-3156 (Table 1). Foliar application of biostimulants shown significant variation with respect to growth parameters. Among different treatments, foliar application of 0.1 % humic acid and 3 % panchagavya along with RDF recorded significantly higher plant height (142.32 cm), number of leaves/plant (25.62), number of tillers/meter row length (83.75), leaf area (18.51 dm^2/plant) and total dry matter production (23.00 g/plant) at harvest compared to application of RDF alone (Table 1).

Among the interaction effects, combination of genotype HMT-100-1 with foliar application of humic acid @ 0.1% and panchagavya @ 3% along with RDF among the interaction has recorded significantly higher plant height (152.33 cm), number of leaves/plant (31.07), number of tillers/meter row length (88.98), leaf area (20.34 dm^2/plant) and total dry matter production (25.30 g/plant) at harvest compared to other treatment combinations.

Experimental results clearly indicated the differential response of treatments with respect to different yield parameters, grain and straw yield due to genotypes and foliar nutrition of biostimulants. Among genotypes, HMT-100-1 recorded significantly higher grain and straw yield (1701.0 and 4066.0 kg/ha respectively) compared to DHFt-109-3 and SiA-3156. Significant increase in yield was due to increase in yield attributing characters of the genotype HMT-100-1. which recorded significantly higher number of panicles per meter row length (64.18), panicle length (16.60 cm), panicle weight (4.47 g), grain weight per panicle (4.02 g) and test weight (3.95 g) (Table 2).

As far as different biostimulants is concerned foliar application of 0.1 % humic acid and 3 % panchagavya along with RDF significantly influenced the yield and yield attributing characteristics by recording higher grain and straw yield (1781.2 kg/ha and 4139.5 kg/ha, respectively). It was mainly attributed to superior yield parameters such as higher number of panicles

Table 2: Yield attributes of foxtail millet as influenced by genotypes and foliar application of biostimulants

Treatments	Number of panicles/m row length	Panicle length (cm)	Panicle weight (g)	Grain weight per panicle (g)	Test weight (g)
Main plots – Genotypes (G)					
G_1	54.12	14.92	4.00	3.63	3.84
G_2	64.18	16.60	4.47	4.02	3.95
G_3	57.45	15.20	4.14	3.73	3.89
S. Em. ±	1.31	0.32	0.06	0.05	0.030
C. D. at 5%	5.29	1.26	0.25	0.22	NS
Sub plots – Foliar nutrition (F)					
F1	62.68	16.28	4.29	3.90	3.88
F2	57.85	15.25	4.22	3.79	3.87
F3	68.69	16.99	4.61	4.33	3.95
F4	45.10	13.77	3.60	3.25	3.87
S. Em. ±	0.86	0.29	0.08	0.07	0.073
C. D. at 5%	2.58	0.87	0.24	0.21	NS
Interaction (G x F)					
G_1F_1	58.64	15.97	3.94	3.55	3.77
G_1F_2	55.36	14.33	3.96	3.56	3.80
G_1F_3	61.17	16.22	4.74	4.27	3.84
G_1F_4	40.95	13.16	3.50	3.15	3.80
G_2F_1	67.41	17.50	4.83	4.34	3.81
G_2F_2	60.44	16.53	4.67	4.21	4.00
G_2F_3	76.83	18.32	4.91	4.42	4.03
G_2F_4	52.03	14.05	3.68	3.33	3.97
G_3F_1	61.64	15.37	4.24	3.82	3.93
G_3F_2	57.76	14.89	4.01	3.61	3.82
G_3F_3	68.07	16.41	4.80	4.32	3.97
G_3F_4	42.32	14.12	3.52	3.17	3.83
S. Em. ±	1.49	0.50	0.13	0.12	0.127
C. D. at 5%	4.44	1.51	0.40	0.36	NS

per meter row length (68.69), panicle weight (4.61 g), panicle length (16.99 cm), grain weight per panicle (4.33 g) and test weight (3.95 g) (Table 2). compared to application of RDF alone without any foliar nutrition of biostimulants (1380.1 kg/ha and 3531.8 kg/ha, respectively). Interaction between genotypes and foliar nutrition of biostimulants showed significant variation in yield and yield parameters. This indicated that the genotypes differed in their phenotypic characters to their interaction with foliar nutrition of biostimulants. Combination of HMT-100-1 with 0.1 % humic acid and 3 % panchagavya along with RDF recorded significantly higher number of panicles per meter row length (76.83), panicle length (18.32 cm), panicle weight (4.42 g), grain weight per panicle (4.42 g), test weight (3.95g), grain and straw yield (2028.1 kg/ha and 4666.6 kg/ha, respectively) (Table 2 and Table 3). Growth parameters are important in deciding the grain yield of any crop.

Table 3: Productivity of foxtail millet as in influenced by genotypes and foliar application of biostimulants

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index
Main plots – Genotypes (G)			
G_1	1408.2	3525.4	0.286
G_2	1701.0	4066.0	0.295
G_3	1538.7	3731.7	0.291
S. Em. ±	39.57	55.69	0.003
C. D. at 5%	159.54	224.57	NS
Sub plots – Foliar nutrition(F)			
F1	1550.6	3791.6	0.290
F2	1485.4	3634.6	0.290
F3	1781.2	4139.5	0.299
F4	1380.1	3531.8	0.283
S. Em. ±	31.77	55.67	0.005
C. D. at 5%	95.39	166.71	NS
Interaction (G x F)			
G_1F_1	1423.5	3532.0	0.288
G_1F_2	1376.2	3460.2	0.284
G_1F_3	1508.5	3710.3	0.287
G_1F_4	1324.7	3399.7	0.283
G_2F_1	1719.2	4111.7	0.295
G_2F_2	1626.0	3840.1	0.297
G_2F_3	2028.1	4666.6	0.303
G_2F_4	1430.6	3645.6	0.284
G_3F_1	1509.2	3731.2	0.288
G_3F_2	1453.8	3603.8	0.287
G_3F_3	1806.9	4041.9	0.307
G_3F_4	1385.0	3550.0	0.282
S. Em. ±	55.03	96.43	0.009

Plant height, number of tillers and leaf area are effectively able to increase the total dry matter accumulation as it is the essential parameter for increasing grain yield. Genotypes and foliar application of biostimulants significantly influenced the growth parameters at all the stages of the crop growth.

The variation in the growth parameters among the genotypes might be due to the variation in their genetic character like higher inter nodal length, high tillering ability which resulted in higher plant height and number of tillers. The increase in the leaf area enhanced the photosynthetic rate which in turn increased its biomass. The results are in accordance with the findings of Reddy *et al*. (2018) in foxtail millet, Sivashankar *et al*. (2020) in finger millet and Kabse *et al*. (2014) in paddy.

Among the foliar nutrition of biostimulants, the development of sound vegetative growth was because of sufficient and liberal availability of nutrients through inorganic sources by RDF and organic sources by biostimulants in soil and foliar application, respectively have resulted in higher metabolic activity in the plant. Humic acid and panchagavya have direct influence on plant growth by inducing metabolic process such as ion uptake, nucleic acid synthesis and regulation of hormone levels resulted in increasing cell division, cell elongation enabled increased growth and development of crop. Similar findings were in line with the findings Manal *et al*. (2016) in wheat, Suruthi *et al*. (2020) in barnyard millet, Ashoka *et al*. (2020) and Naik *et al*. (2018) in foxtail millet.

Yield depends upon various factors related to the plant and environment. Maximization of the grain yield of any crop genotypes mainly depends upon processes associated with uptake of nutrients, their mobilization, translocation, partitioning and assimilation during different crop growth stages. These processes are mainly influenced by genetic potential of the genotypes, soil and climatic factors and cultural practices followed during cultivation.

The magnitude of increase in grain and straw yield with the superior genotype HMT-100-1 was to an extent of 20.80 % grain yield and 15.42 % straw yield over low yielding genotype SiA-3156 (Table 3 and Figure 1). It might be due to the fact that gen0types are different in their yielding potential depending on many physiological processes taking place in different plant parts, and are controlled by both the genetic makeup of the plant and the environment. These results are in agreement with the findings of Brunda *et al*. (2014), Srikanya *et al*. (2020) and Jyothi *et al*. (2016) in foxtail millet.

Among the foliar application treatments, there was an improvement in grain and straw yield to an extent of 29.05 % in grain and 16.28 % respectively over control (Table 3 and Figure 1). Soil application of nutrients provide scope for the development of the plant but is also subjected to various losses due to climate abnormalities like heavy or deficit rainfall *etc.* Hence, providing additional nutrient supply through the foliar application of biostimulants *viz*., humic acid and panchagavya which facilitate easy and quick nutrient absorption through their stomata and epidermis. They contain growth promoting substances like Indole acetic acid (IAA), gibberellins and auxins in its structure along with beneficial microorganisms. When these liquid manures applied twice at critical stages of the plant growth and development, they act as a stimulus in the plant system increases the translocation of the photosynthates from source to sink and nutrient uptake by the crop ultimately leads to higher yield. These results are in conformity with the findings of Kumaran and Parasuraman. (2019) in foxtail millet, Patel *et al.* (2021) in pearl millet, Vanitha and Mohandas (2014) in paddy and Gokul and Senthilkumar (2019) in finger millet.

Combined effect of the genetic potential of the genotype to adopt for the climate of that area and additional supply of nutrient through the biostimulants along with the RDF made significant increase in the yield of the crop. The results are in conformity with the findings of Atish *et al*. (2019) in foxtail millet and Ahmed *et al*. (2016) in proso millet.

Conclusion

The results of the present investigation clearly indicated that providing additional supply of nutrients along with soil application of recommended dose of fertilizers increase the growth and yield of foxtail millet. It has the potential to improve the productivity of the foxtail millet grown in medium to low fertile soils also. Hence, cultivation of HMT-100-1 with foliar application of 0.1 % humic acid and 3 % panchagavya along with soil application of RDF becomes more suitable practice when compare to cultivation of other genotypes and application of RDF alone for growing foxtail millet under late sown condition of *Kharif* season in Southern Transition Zone of Karnataka.

Conflict of interest

The authors declare that they have no conflict of interest.

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