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Prashant
Department of Agronomy, College of Agriculture, Shivamogga Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Hugar AY
Department of Agronomy, College of Agriculture, Shivamogga Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Mavarkar NS
Department of Agronomy, College of Agriculture, Shivamogga Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Sarvajna B Salimath
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Shivamogga Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Nandish MS
Department of Agricultural microbiology, College of Agriculture, Shivamogga Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Corresponding Author:
Prashant
Department of Agronomy, College of Agriculture, Shivamogga Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Influence of foliar nutrition of humic acid on growth and growth indices of Foxtail millet (*Setaria italica* L.)

Prashant, Hugar AY, Mavarkar NS, Sarvajna B Salimath and Nandish MS

Abstract
A field experiment was conducted to evaluate the effect of foliar nutrition and humic acid on growth and growth indices of Foxtail millet (*Setaria italica* L.) at Agricultural and Horticultural Research Station (AHRS) Bavikere, Tarikere taluk, Chikamagalur district, during late *kharif* 2020. The experiment consisted of eight treatments and three replication and laid out in RCBD design. Treatments details of experiment consist of *viz.*, Only RDF (T_1), foliar application of 1% urea along with RDF(T_2), foliar application of 0.2% sulphate of potash along with RDF(T_3), foliar application of 0.1% humic acid along with RDF(T_4), foliar application of 1% urea, 0.2% sulphate of potash along with RDF(T_5), foliar application of 1% urea, 0.1% humic acid along with RDF(T_6), foliar application of 0.2% sulphate of potash, 0.1% humic acid along with RDF(T_7) and foliar application of 1% urea, 0.2% sulphate of potash, 0.1% humic acid along with RDF(T_8). Results indicated that, foliar application of 1% urea, 0.2% sulphate of potash and 0.1% humic acid along with RDF (T_8)recorded significantly higher leaf area (cm^2 $plant^{-1}$), leaf area index, leaf area duration (days), total dry matter accumulation (g/plant), absolute growth rate (g $plant^1 day^{-1}$), crop growth rate (g m^{-2} day^{-1}), relative growth rate (g g^{-1} day^{-1}) at all the growth stages of crop.

Keywords: Foxtail millet, foliar nutrition, humic acid, growth and growth indices

Introduction
Foxtail millet is one of the oldest cultivated small millets both for food and fodder. It ranks second in the total world production of millets and it continues to have an important place in world agriculture providing food for millions of people in arid and semiarid regions. It is native to China and regarded as an elite drought tolerant crop (Cheng and Liu, 2003) [1].
Importance of small millets is gaining ground in recent years to ensure food security to the younger generations. The most urgent and the strong context for giving such a priority to millet's, is provided by the coming decades of "Climate Change" which confront us with three challenging scenarios *viz.*, global warming, water scarcity and health disorders. Being drought, temperature and pest tolerant crops, small millet's are considered as the grains for the future.
More recently, foliar application has been widely used and accepted as an one of the effective technique that could be effective for 6 - 20 times more than soil application to achieve higher crop productivity and production. The benefits of foliar feeding have been well documented and increasing efforts have been made to achieve consistent responses. Foliar application is a technique of feeding plants by applying liquid fertilizer directly to their leaves. Plants are able to absorb essential elements through their leaves. The absorption takes place through their stomata and also through their epidermis. It is the application of fertilizers to foliage of the crop as spray solution is known as foliar spray. Foliar application of urea and growth regulators at flowering stage may improve the physiological efficiency and may play a significant role in raising the productivity of the crop (Dashora and Jain, 2011) [2].
Natural organic substances such as humic acid play an essential role in ensuring soil fertility and plant nutrition. Addition of such molecules either to the soil or through foliar application along with adequate amount of conventional fertilizers improves the efficiency of applied fertilizers apart from promoting the conversion of unavailable form of nutrients to available forms. The organic compounds prepared from humic substances have chelating, plant growth stimulating effects and positive effect on the growth of various groups of microorganisms.

Materials and Methods
The field experiment was conducted at Agriculture and Horticultural Research Station,

Bavikere, Tarikere taluk, Chikamagalur districtduring late *kharif* 2020 to know the effect of foliar nutrition and humic acid on growth and growth indices of Foxtail millet (*Setaria italica* L.). The experimental site is located at Southern Transition Zone of Agro- climatic zone-VII of Karnataka between 75°51` E longitude and 13°42` N at an altitude of 695 meters above the mean sea level. The soil was sandy loam in texture, acidic in reaction (5.52), high organic carbon (0.81%), medium available nitrogen (280.23 kg ha^{-1}), high available phosphorus (66.80 kg ha^{-1}) and medium in available potassium (235.78 kg ha^{-1}). The experiment included eight treatments and replicated thrice *viz.*, Only RDF (T_1), foliar application of 1% urea along with RDF(T_2), foliar application of 0.2% sulphate of potash along with RDF(T_3), foliar application of 0.1% humic acid along with RDF(T_4), foliar application of 1% urea, 0.2% sulphate of potash along with RDF(T_5), foliar application of 1% urea, 0.1% humic acid along with RDF(T_6), foliar application of 0.2% sulphate of potash, 0.1% humic acid along with RDF(T_7) and foliar application of 1% urea, 0.2% sulphate of potash, 0.1% humic acid along with RDF(T_8) and farm yard manure was common for all treatments @ 5 tonnes per hecter. Three replication laid out in randomised complete block design with net plot size of 3.0 m × 3.2 m. The land was well ploughed to make a fine seed bed. "SiA 3156" variety of Foxtail millet seeds were used for sowing @ 8 kg ha^{-1}. The crop was commonly applied with recommended dose of fertilizer were applied in the form of urea (N), Sulphate of Potash (P_2O_5) and Di-ammonium phosphate (K_2O) as per the calculated amount to each plot and as basal dose at the time of sowing to all the treatments. Protective irrigation was supplied to crop requirement as per the need of the crop and two to three hand weeding were done to reduce crop-weed competition. Harvesting and threshing operations were done manually by separating each plot and sun dried before threshing after that straw and grain of each plots were weighed and tagged separately.

The biometric observations like leaf area (cm^2 $plant^{-1}$), leaf area index, leaf area duration (days), total dry matter accumulation ($gplant^{-1}$), absolute growth rate (g $plant^1 day^{-1}$), crop growth rate (g m^{-2} day^{-1}), relative growth rate (g g^{-1} day^{-1}) were according to their formulae

The leaf area ($cm^2 plant^{-1}$) was recorded using leaf area meter. Leaf area of five labeled plants was averaged and taken as leaf area $plant^{-1}$.

Leaf area index (LAI) was calculated by using the formula suggested by (Sestak *et al.*, 1971) [6].

$$\text{LAI} = \frac{\text{Leaf area (cm}^2)}{\text{Land area (cm}^2)}$$

Leaf area duration is computed by using the following formula

$$\text{LAD} = \frac{\text{LAI}_1 + \text{LAI}_2}{2} \times (t_2 - t_1)(\text{Power } et\ al., 1967)$$

Where

LAI = Leaf area index

t_1=LAI at time t_1

t_2= LAI at time t_2

Total dry matter accumulation ($gplant^{-1}$) was recorded using plant samples which were dried separately at $65^0C \pm 5$ in hot air oven till attainment of constant weight. Completely dried samples were weighed and the total dry weight of plant was expressed in gram per plant.

Absolute growth rate (g $plant^1 day^{-1}$) is calculated by using the following formula

Where, W_1 and W_2 are dry weights of plant at time t_1 and t_2, respectively

$$\text{AGR} = \frac{W_2 - W_1}{t_2 - t_1}\ g\ p^{-1}\ day^{-1} (\text{Radford}, 1967)$$

Where, W_1 and W_2 are dry weights of plant at time t_1 and t_2, respectively Crop growth rate is computed by using the following formula

$$\text{CGR} = \frac{W_2 - W_1}{(t_2 - t_1) \times A}\ (g\ cm^{-2}\ day^{-1})(\text{Watson}, 1952)$$

Where, W_1 and W_2 are dry weights of plant at time t_1 and t_2, respectively and A-spacing.

Relative growth rate is computed by using the following formula

$$\text{RGR} = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}\ g\ g^{-1} day^{-1} \left(\text{Watson } et\ al., 1963\right)$$

Where, W_1 and W_2 are dry weights of plant at time t_1 and t_2 respectively. Loge, natural logarithm.

Results and Discussion

Growth and growth indices

The data on growth parameters like leaf area (cm^2 $plant^{-1}$), leaf area index, leaf area duration (days), total dry matter accumulation ($gplant^{-1}$), absolute growth rate (g $plant^1 day^{-1}$), crop growth rate (g m^{-2} day^{-1}), relative growth rate (g g^{-1} day^{-1}) as significantly influenced by foliar nutrition and humic acid.

Leaf area recorded at 30, 60 DAS and at harvest of Foxtail millet as influenced by foliar nutrition and humic acid is presented in Table 1.

The results revealed that foliar nutrition of 1% urea, 0.2% sulphate of potash and 0.1% humic acid along with RDF (T_8) registered maximum leaf area (410.0, 772.5 at 30, 60 DAS and 243.2 cm^2 per plant at harvest) which was on par withT_6 (397.5, 765.3 at 30, 60 DAS and 238.6 cm^2 per plant at harvest) and While, lowest leaf area per plant (341.2, 596.8 at 30, 60 DAS and 146.5 cm^2 per plant at harvest) was recorded in T_1 that received only RDF without any foliar nutrition. The percentage increase over control for leaf area was upto (20.16%, 29.4% at 30, 60 DAS and 66% at harvest respectively) This might be because of sufficient and liberal availability of nutrients through both organic and inorganic sources as both soil and foliar application under enough soil moisture during the crop growth period might have resulted in higher metabolic activity of the plant (Veysel *et al*. 2011) [8].

Table 1: Leaf area (cm^2 $plant^{-1}$) of Foxtail millet as influenced by foliar nutrition and humic acid

Treatment	30 DAS	60 DAS	At harvest
	(cm^2 $plant^{-1}$)		
T_1	341.20	596.80	146.50
T_2	356.17	672.50	198.57
T_3	342.80	671.20	163.50
T_4	356.50	675.80	199.80
T_5	358.00	682.33	211.27
T_6	397.50	765.30	238.60
T_7	377.40	696.53	216.53
T_8	410.00	772.50	243.20
S.Em.±	13.26	21.18	10.82
C.D.@ 5%	40.22	64.25	32.81

Leaf area index is calculated by dividing the leaf area per plant by land area occupied by the plant

Leaf area index calculated at 30, 60 DAS and at harvest followed the same trend as that of leaf area and is presented in Table 2.

The result revealed that foliar nutrition of 1% urea, 0.2% sulphate of potash and 0.1% humic acid along with RDF (T_8) registered significantly higher leaf area index (1.37 at 30 DAS, 2.56 at 60 DAS and 0.81 at harvest) which was on par with T_6 (1.26 at 30 DAS, 2.55 at 60 DAS and 0.80 at harvest) Significant reduction in leaf area index (1.14 at 30 DAS, 1.99 at 60 DAS and 0.49 at harvest) was recorded in T_1 which was supplied with only RDF without any foliar nutrition. The percentage increase over control for leaf area index was upto (0.11%, 0.20% at 30, 60 DAS and 0.05% at harvest respectively) This might be attributed to efficient photosynthetic structure that supported a greater synthesis, accumulation, partitioning and translocation of photosynthates to different parts of the plants which might have facilitated increased growth and development of crop in terms of leaf area (Suruthi *et al*. 2019) [7].

Table 2: Leaf area index of Foxtail millet as influenced by foliar nutrition and humic acid

Treatment	Leaf area index		
	30 DAS	60 DAS	At harvest
T_1	1.14	1.99	0.49
T_2	1.19	2.24	0.66
T_3	1.14	2.24	0.55
T_4	1.19	2.27	0.67
T_5	1.19	2.25	0.70
T_6	1.26	2.55	0.80
T_7	1.33	2.32	0.72
T_8	1.37	2.58	0.81
S.Em.±	0.04	0.07	0.04
C.D.@ 5%	0.13	0.10	0.11

Leaf area duration is the integral of leaf area index over a growth period and expressed in days. Leaf area duration of a crop is a measure of its ability to produce leaf area on unit area of land over a time period.

Significantly higher leaf area duration was recorded in treatment T_8 which received foliar nutrition of 1% urea, 0.2% sulphate of potash and 0.1% humic acid along with RDF (20.5 at 0 - 30 DAS, 59.13 at 30 - 60 DAS and 42.32days at 60 DAS - at harvest) which was on par with T_6 (18.87 at 0 - 30 DAS, 57.14 at30 - 60 DAS and 41.83days at 60 DAS - at harvest). Significant reduction in leaf area duration (17.06 at 0 - 30 DAS, 46.9 at 30 - 60 DAS and 30.97days at 60 DAS - at harvest) was recorded in T_1 which was supplied with only RDF without any foliar nutrition. and the percentage increase over control for leaf area duration (20% at 0 - 30 DAS, 26% at 30 - 60 DAS and 36% at 60 DAS -at harvest respectively) and is presented in Table 3.

Table 3: Leaf area duration (days) of Foxtail millet as influenced by foliar nutrition and humic acid

Treatment	LAD (days)		
	0- 30 DAS	30 - 60 DAS	60 DAS - harvest
T_1	17.06	46.90	30.97
T_2	17.81	51.43	36.29
T_3	17.14	50.70	34.78
T_4	17.83	51.94	36.76
T_5	17.90	51.69	36.96
T_6	18.87	57.14	41.83
T_7	19.88	54.70	38.04
T_8	20.50	59.13	42.32
S.Em.±	0.66	1.47	1.23
C.D.@ 5%	2.01	4.45	3.72

Dry matter accumulation in crop plants is a complex physiological process and plant dry weight measured at a specific crop growth stage is complex trait of which initial dry weight and increase in dry weight over the period of growth are two major components of dry matter production. Dry matter act as an indicator of availability of soil moisture and nutrients along with favourable climatic conditions. Presented in Table 4.

The treatment that received foliar nutrition of 1% urea, 0.2% sulphate of potash and 0.1% humic acid along with RDF (T_8) excelled over all other treatments by registering maximum total dry matter accumulation (3.46 at 30 DAS, 11.90 at 60 DAS and 23.65 g per plant at harvest) which was on par with T_6 (3.29 at 30 DAS, 10.87 at 60 DAS and 22.80 g per plant at harvest) and the lowest total dry matter accumulation (2.29 at 30 DAS, 6.91 at 60 DAS and 13.21 g per plant at harvest) was recorded in T_1 which was supplied with only RDF without any foliar nutrition. The magnitude of increase with respect to dry matter accumulation (51.0% at 30 DAS, 72.2% at60 DAS, 79.0% at harvest respectively) and same trend was followed in grain yield and this might be because foliar application of urea, sulphate of potash and humic acid may be attributed to increasing nitrogen content in the plant system which in turn might have resulted in more synthesis of nucleic acids, amino acids etc., in growing regions, meristamatic tissues ultimately increasing cell division and multiplication there by accumulating more and more of dry matter in the plants as a result higher growth and development was noticed and similar results were noticed by (Rajesh and Paulpandi, 2013) [5] in Redgram.

Table 4: Total dry matter accumulation (g $plant^{-1}$) and grain yield (kg ha^{-1}) of Foxtail millet as influenced by foliar nutrition and humic acid

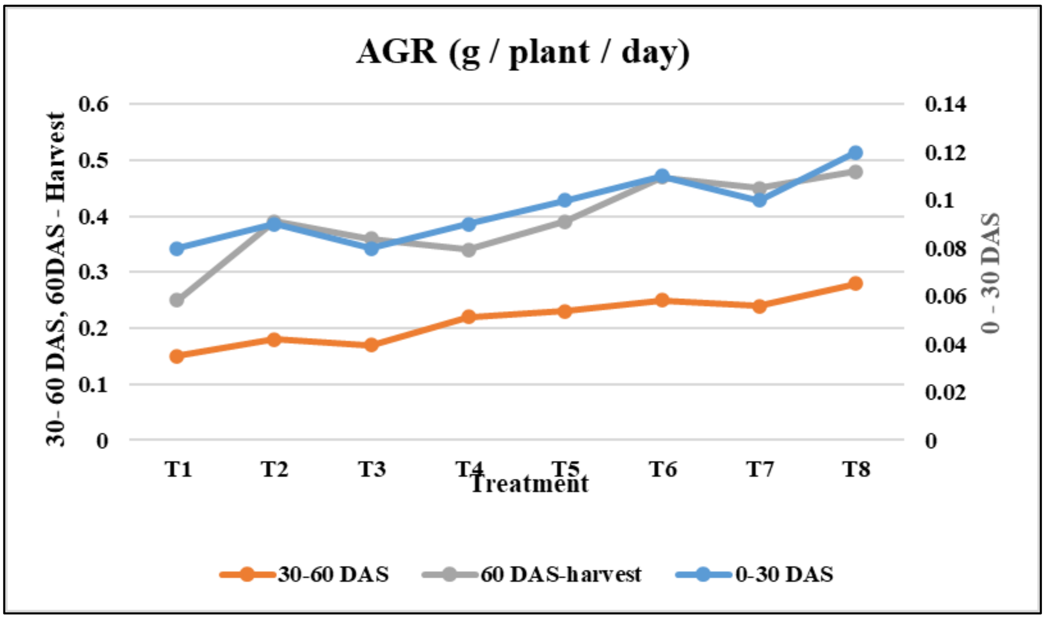
Treatment	30 DAS	60 DAS	At harvest	Grain yield
	(g $plant^{-1}$)			(kg ha^{-1})
T_1	2.29	6.91	13.21	1220.0
T_2	2.57	7.84	17.65	1323.3
T_3	2.32	7.46	16.45	1270.0
T_4	2.84	9.36	17.86	1630.0
T_5	3.08	10.06	19.76	1800.0
T_6	3.29	10.87	22.80	1903.3
T_7	3.13	10.47	21.65	1833.3
T_8	3.46	11.90	23.65	2076.7
S.Em.±	0.10	0.30	0.74	83.70
C.D.@ 5%	0.31	0.91	2.26	253.86

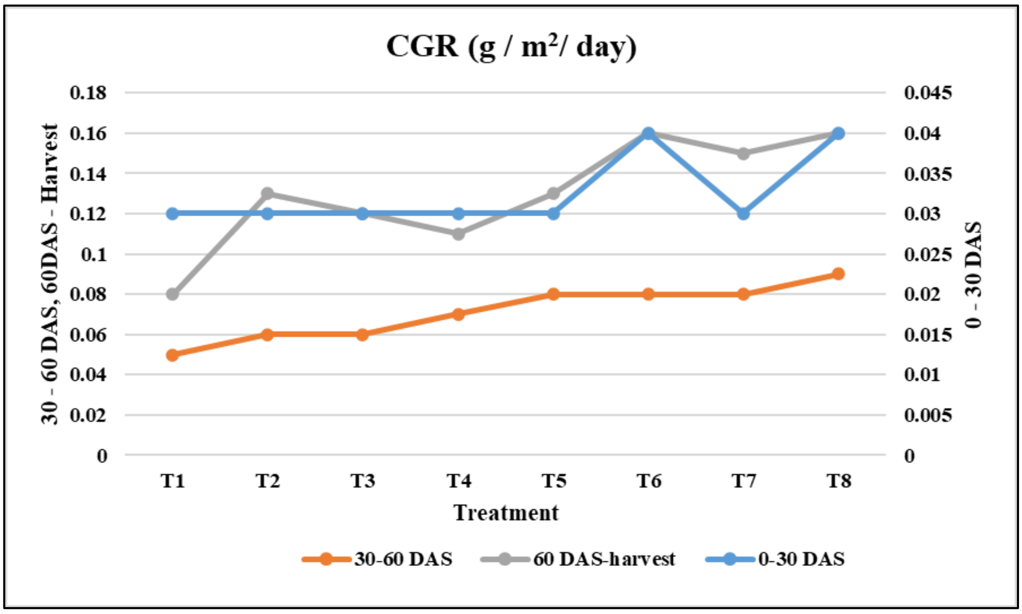
Absolute growth rate is expressed as the dry weight increase per unit time and is expressed in g plant^{-1} day^{-1}.

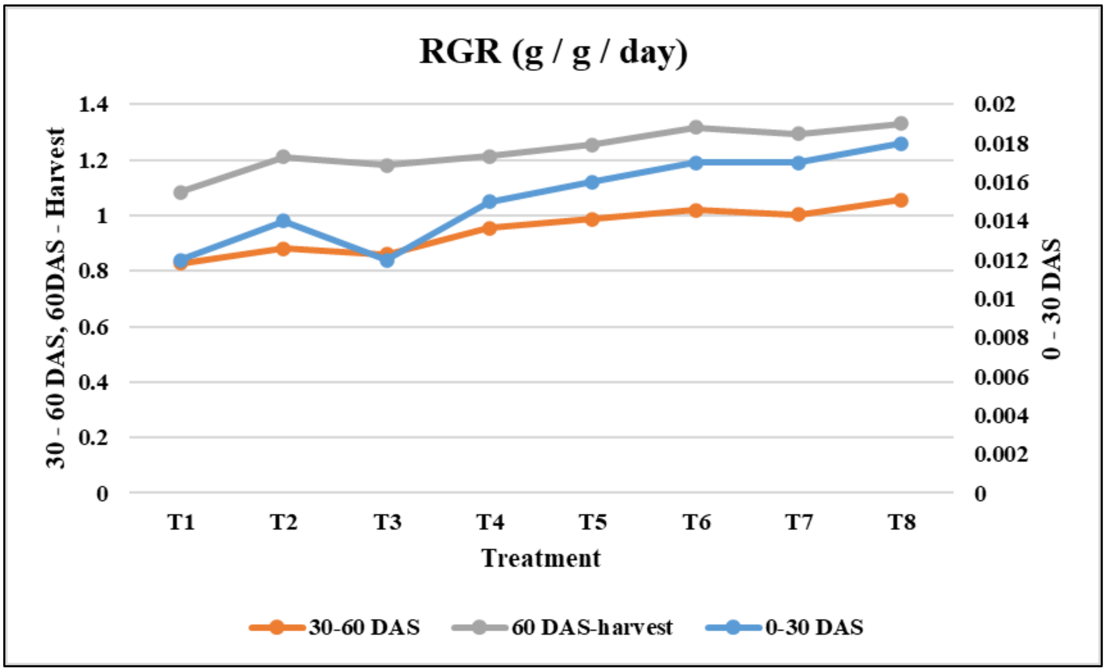
Crop growth rate represents dry weight grain by a unit area of crop in a given time. It is expressed in g m^{2} day^{-1}.

Relative growth rate of crops at time instant (t) is defined as the increase of plant material per unit weight per unit time. It is expressed in g g^{-1} day^{-1}.

Significantly higher absolute growth rate (0.12 at 0 - 30 DAS, 0.28 at 30 - 60 DAS and 0.48 g plant^{1} day^{-1} at 60 DAS - harvest), crop growth rate (0.04 at 0 - 30 DAS, 0.09 at 30 - 60 DAS and 0.16 g m^{-2} day^{-1} at 60 DAS - harvest) and relative growth rate (0.018 at 0 - 30 DAS, 1.057 at 30 - 60 DAS and 1.331 g g^{-1} day^{-1} at 60 DAS - harvest) was recorded with application of RDF along with foliar nutrition of 1% urea, 0.2% sulphate of potash and 0.1% humic acid. However, significant reduction in absolute growth rate (0.08 at 0-30 DAS, 0.15 at 30-60 DAS and 0.25 g plant^{-1} day^{-1} at 60 DAS - harvest), crop growth rate (0.03 at 0 - 30 DAS, 0.05 at 30 - 60 DAS and 0.08 g m^{-2} day^{-1} at 60 DAS-harvest) and relative growth rate (0.012 at 0 - 30 DAS, 0.827 at 30 - 60 DAS and 1.084 g g^{-1} day^{-1} at 60 DAS - harvest) was recorded with application of RDF without any foliar nutrition. This may be due to foliar application of humic acid compounds may have various biochemical effects either at cell wall, membrane level or in the cytoplasm, including increased photosynthesis and respiration rates in the plants. Foliar application of urea retarded the loss of chlorophyll and enhanced the rate of photosynthesis (Anamika and Dhaka, 2003) results are presented in Fig 1.







Treatment details
T_1: Only RDF (No foliar application)
T_2: Foliar application of 1% urea at 25 and 35 DAS
T_3: Foliar application of 0.2% SOP at 25 and 35 DAS
T_4: 0.1% humic acid foliar spray at 25 and 35 DAS
T_5: Foliar application of 1% urea + 0.2% SOP at 25 and 35 DAS
T_6: 1% urea + 0.1% humic acid foliar spray at 25 and 35 DAS
T_7: 0.2% SOP + 0.1% humic acid foliar spray at 25 and 35 DAS
T_8: 1% urea + 0.2% SOP + 0.1% humic acid foliar spray at 25 and 35 DAS

Fig 1: Absolute growth rate (g plant^{-1} day^{-1}), Crop growth rate (g m^{-2} day^{-1}), Relative growth rate (g g^{-1} day^{-1}) of Foxtail millet as influenced by foliar nutrition and humic acid.

Growth and development of any crop depends on assimilatory surface in terms of leaf area, total dry matter accumulation and its derivatives like leaf area index, leaf area duration, absolute growth rate, crop growth rate, relative growth rate significantly increased by foliar application of urea, Sulphate of Potash and humic acid along with RDF which ultimately increased grain and straw yield.
The present investigation entitled "Effect of foliar nutrition and humic acid on growth and growth indices of Foxtail millet (*Setaria italica* L.). it can be concluded that foliar application of of 1% urea, 0.2% sulphate of potash and 0.1% humic acid along with RDF excelled over all other treatments by registering maximum growth and growth attributes.

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